



SMART TECHNOLOGY FOR HEALTHY LONGEVITY:

REPORT OF A STUDY

BY THE

AUSTRALIAN ACADEMY OF
TECHNOLOGICAL SCIENCES
AND ENGINEERING (ATSE)



SMART TECHNOLOGY FOR HEALTHY LONGEVITY

The key finding of this report by the Australian Academy of Technological Sciences and Engineering is that a national thrust on the development and application of smart technology for healthy longevity is vital to ensure a healthy, safe, secure and fulfilling future for the increasing aged population in Australia and the maintenance of a healthy, harmonious and prosperous society.

MAY 2010

SMART TECHNOLOGY FOR HEALTHY LONGEVITY:
Report of a Study by the Australian Academy of Technological Sciences and Engineering

© Australian Academy of Technological Sciences and Engineering (ATSE)

ISBN 978 1 921388 11 8

This work is copyright. Apart from any use permitted under the Copyright Act 1968, no part of it may be reproduced by any process without written permission from the publisher. Requests and inquiries concerning reproduction rights should be directed to the publisher.

Publisher

Australian Academy of Technological Sciences and Engineering
Level 1/ 1 Bowen Crescent
Melbourne Victoria 3004 Australia
GPO Box 4055
Melbourne Victoria 3001 Australia

Telephone +613/03 9864 0900

Facsimile +613/03 9864 0930

Website www.atse.org.au

Author: Professor W J McG Tegart AM FTSE

This work is also available as a PDF document on the ATSE website, www.atse.org.au

This project was funded by the Australian Research Council, Linkage Learned Academies Special Projects (LASP) scheme.

Design and production: Coretext, www.coretext.com.au

Printing: FSG Print Management, www.fsg.com.au

Date of Publication: May 2010

Cover: iStockphoto

Executive Summary

With the demographic ageing of Australia's population, a suite of emerging innovative technologies offers the prospect of enhanced security, safety, diagnosis, treatment and physical assistance to improve the quality of life for elderly people, to help them remain at home, and to provide financial savings in aged care and medical treatment.

There is already a substantial investment in research and development capacity in this area in Australia but more needs to be done to maintain, strengthen and coordinate this activity and to ensure that public and private aged care authorities and organisations can effectively utilise the outcomes. The Australian Government has a critical role to play by promoting a National Research and Development Agenda on Technology and Ageing to complement the National Strategy on Ageing and the recently announced National Enabling Technologies Strategy.

In general, people are living longer and birth rates are falling. The balance of the population between older and younger people is undergoing a dramatic change. The reshaping of the age distribution will affect all sectors of society and the nation needs to act now to deal with potential issues. This changing demographic pattern is occurring in all developed countries and an increasing number of developed countries. It is happening considerably faster in Europe and many Asian countries than here because of Australia's continued high immigration rate.

Population ageing presents a major economic challenge because a smaller proportion of people of working age will have to support the cohort of people who are retired. In Australia the demographic support ratio, that is, the number of people of working age (20 to 64) relative to older people (65+), will fall from the present ratio of 5:1 down to 2.7:1 by 2050. This means that productivity must be increased to maintain economic growth and that there will be a shortage of healthcare professionals and carers to cope with the increased number of frail elderly.

Because the elderly are more frequent users of health services and because medical researchers are developing new drugs and procedures linked to age, the Australian Government's 2010 Intergenerational Report suggests that health spending on those aged over 65 is likely to increase sevenfold. There will be a need for new models of health care and training to deal with this situation. Technology can offer possible solutions to issues of safety and security, diagnosis and treatment, while assistive technologies offer the potential to reduce costs.

Ageing-in-place supported by smart technologies offers the potential for substantial savings in residential aged care and in reduced admissions to hospitals, by providing early alerts to changing health patterns and by minimising falls and other accidents in the home. Many of these technologies for elderly-friendly housing depend on information and communication technologies to address social communications, personal health monitoring, telehealth, shopping and education. While these can be installed in existing homes, future dwellings will need to be custom designed to incorporate such systems and to cater for the lifelong needs of people. There are opportunities for business and industry to capitalise on the projected expanded markets, both in Australia and overseas, offered by demographic change.

Because of the complexities of the challenges that need to be addressed in applying technology to the aged, there is a need to bring together a wide range of technologies to focus on solutions. The Australian Government has recognised the value of this approach in the recently announced National Enabling Technologies Strategy. The concept of enabling technologies brings into convergence several

technologies such as nanotechnologies, information and communication technologies, biotechnology and cognitive science to focus on areas of social, economic and technical importance. In Europe their application to ageing is termed 'gerontechnology', linking medical aspects of ageing (gerontology) with smart technologies to assist in daily living. This is a well-established concept overseas that needs to be promoted in Australia as a means to coordinate research and development activity in this area.

The present study has reviewed much of the overseas activity in gerontechnology, particularly in Europe where there are well organised and well funded national and multi-national programmes. An EU/Australia workshop in Paris in October 2009 provided an up-to-date view of European activity. Based on these inputs and extensive discussions in Australia in three workshops organised by the Australian Academy of Technological Sciences and Engineering (ATSE), together with numerous visits to researchers and interested groups, several technological opportunities for Australia have been identified within a timeframe of 15 to 20 years. Selected technologies are in three categories:

- security and safety – elderly-friendly homes, prevention of falls, communication and social interaction;
- diagnosis and treatment – telehealth, coping with degenerative diseases, nanomedicine; and
- assistive technologies – biorobotics, brain/machine interaction, mobility systems.

To realise the potential of smart technology in these categories in Australia, national coordination is essential to make optimum use of the available resources, while sustained R&D support is needed. Universities need to bring together a range of skills in Centres of Excellence in Gerontechnology to provide research and training in the application of smart technologies for healthy longevity. Healthcare authorities, the insurance industry and the public need to be made aware of the potential of smart technologies to assist in providing healthy, secure and happy futures for the aged population. Further, Australian business and industry need to be alerted to opportunities for commercialisation of outputs from gerontechnology R&D. Such an approach is in accord with the objectives of the National Enabling Technologies Strategy.

Finally, there are important social and ethical issues raised by the application of technologies to aged people. They should be involved more deeply in defining their needs to ensure optimum solutions. Outcomes should be 'demand-driven' and not a result of 'technology-push'. With closer linkages via home communication systems there are increased opportunities for loss of privacy, fraud, misuse of personal information etc, particularly with the frail aged. The issue of privacy is a major one arising from the use of unseen monitoring systems which report to a central base. These issues must be addressed in the development and application of enabling technologies for the ageing.

Recommendations

1 There is an urgent need for the Australian Government Departments of Health and Ageing (DOHA) and of Innovation, Industry, Science and Research (DIISR) to develop a National Research and Development Agenda on 'Technology and Ageing' to ensure national coordination of existing programs relevant to gerontechnology, that is, the linking of medical aspects of ageing to advanced technologies. This approach would complement the National Strategy for an Ageing Australia and the National Enabling Technologies Strategy and would be in line with the Australian National Research Priorities.

Gerontechnology is an area which can make a substantial input to meeting the economic and social challenges posed by the changing demographics in Australia. Recent projections of 7.7 million aged over 65 and 1.8 million aged over 85 by 2050 are particularly striking in view of implications for housing, health care and infrastructure. The application of smart technologies to issues of ageing offers opportunities for savings in the public and private sectors plus improved quality of life for seniors.

2 Such a National Research and Development Agenda on Technology and Ageing must identify priority areas and also ensure sufficient funding for their research and associated commercialisation.

Current activity is widely dispersed in a number of areas in universities and research institutes. A starting point for coordination is the identification in this report of nine opportunity areas for Australia, in three groupings:

- security and safety – elderly friendly homes, prevention of falls, communication and social interaction;
- diagnosis and treatment – telehealth, coping with degenerative diseases, nanomedicine; and
- assistive technologies – biorobotics, brain/machine interaction, mobility systems.

These opportunity areas link nanotechnology, biotechnology, ICT and cognitive science in accord with the objectives of the National Enabling Technologies Strategy.

3 Where clusters of expertise exist, universities and research institutes should be encouraged through joint ARC/NHMRC support to set up Centres of Excellence in Gerontechnology.

Such Centres have been set up in a number of universities in Europe and North America and can serve as models. The application of technology to the aged population must be based on identification of their needs and on human-centred design, not on technology-push. The active involvement of aged people, physicians working in aged care, social scientists, designers and ethicists in Centres of Excellence in Gerontechnology is essential for successful outcomes of research and development programs.

The creation of a Cooperative Research Centre on Smart Technology for Healthy Longevity would be a significant step to link research more closely to business, industry and seniors.

4 The concept of ageing-in-place to enable independent living for the aged population needs to be recognised as an essential component of the National Strategy for an Ageing Australia.

The European experience shows that this will provide a focus for much of the research and development in gerontechnology and will highlight areas needing change such as models of care and training of the

health workforce, communication protocols for wireless links, device and product development, and the standardisation of building requirements via the Building Code of Australia.

5 The Australian Government Department of Education, Employment and Workplace Relations (DEEWR) should establish a Taskforce drawn from relevant Skills Councils to identify the training and accreditation needs of a future gerontechnology workforce operating in the home environment. This should be seen as a component of the National Health Workforce Strategic Framework.

There is a need to ensure that there will be a critical mass of trained and accredited technicians and paraprofessionals capable of installing, maintaining and applying the array of gerontechnology products and devices available to support the increasing cohort of the aged population in their home environments. New courses in TAFE and Higher Education programs will be needed, as are now available in Europe.

6 The Productivity Commission should be tasked by the Australian Government to carry out a study of the potential savings arising from maintaining seniors safely, securely and happily in their own homes for an average of five to 10 years more than at present by using technologies that are available or under development in Australia.

This would build on its 2005 report on economic implications of ageing in Australia and provide input to Treasury for its next Intergenerational Report.

7 The Privacy Commissioner should be tasked by the Australian Government to examine issues of privacy in the application of technologies to the aged population.

The issue of privacy is particularly important where there is a strong risk of 'technological paternalism', in which healthcare systems use technology in the home environment to control people in their perceived best interests.

8 DIISR should actively seek to ensure Australian participation in international programs and projects on gerontechnology to amplify our limited resources and gain access to new findings.

Europe in particular has well-organised and well-funded programs, both national and Europe-wide, and contacts have been established through the EU/Australia Workshop in Paris in October 2009. These linkages must be actively supported through funding for mutual visits and joint projects. Participation in EU programs needs to be encouraged.

9 Medicare and the health insurance industry need to assess the potential of new technologies to reduce serious accidents and other events which can lead to hospitalisation of elderly people, and to implement mechanisms that encourage the application of new technologies.

Many health funds are prepared to subsidise the cost of long-term preventative measures such as gym memberships. Subsidies for the application of new products and devices to maintain independent living for elderly people, particularly in the home environment, have the potential to reduce future insurance claims.

Acknowledgements

The Academy is most grateful to the contributions made by the author of the report and the Steering Committee established to oversee the conduct of the project.

A brief background of the author of the report is given below:

Professor W.J. McG. (Greg) Tegart AM FTSE

After retiring from the Australian Public Service in 1993 as Secretary, Australian Science and Technology Council, Professor Tegart held positions as a Visiting Professor of Science Policy at the University of Canberra and as a Distinguished Visiting Fellow at the National Europe Centre at the Australian National University in Canberra studying S&T relations between Australia and Europe. He has held various positions (currently Adjunct Professor) at the Centre for Strategic Economic Studies at Victoria University in Melbourne. He was one of the founding Co-Directors in 1998 of the APEC Center for Technology Foresight in Bangkok (funded by the Royal Thai Government) and was then Executive Adviser and recently Chair of the International Advisory Board. He is the author and editor of several books and has published some 250 articles on a wide variety of scientific and technical topics.

This project was overseen on behalf of the Academy by a Steering Committee:

- Professor Robin Batterham AO FAA FREng FTSE – President, ATSE
- Dr Vaughan Beck FTSE – Executive Director, Technical, ATSE
- Mr Keith Daniel FTSE
- Dr Alan Finkel AM FTSE
- Dr Bob Frater AO FAA FTSE
- Professor Peter Hudson FTSE
- Mr Peter Laver AM FTSE – Vice President, ATSE (Chair)
- Professor Graham Mitchell AO FAA FTSE
- Dr Craig Mudge FTSE
- Professor Peter Newton – Swinburne University of Technology
- Professor Greg Tegart AM FTSE
- Dr Terry Turney FTSE
- Professor John Weckert – Charles Sturt University

This project was established and managed for ATSE by:

- Dr Vaughan Beck – FTSE, Executive Director, Technical, ATSE

The production of this publication was overseen by:

- Mr Bill Mackey – Executive Director, Communications, ATSE.

The Australian Academy of Technological Sciences and Engineering, ATSE, gratefully acknowledges funding provided by the Australian Research Council (ARC) under the Linkage Learned Academies Special Projects program to support the conduct of this project.

SMART TECHNOLOGY FOR HEALTHY LONGEVITY

Contents

EXECUTIVE SUMMARY	i
RECOMMENDATIONS	iii
ACKNOWLEDGEMENTS	v
1. BACKGROUND, AIM AND SCOPE OF THIS STUDY	1
2. THE CHALLENGE OF AN AGEING SOCIETY IN AUSTRALIA	3
2.1 Changing demographics	3
2.2 Health and social Implications of the future ageing population	5
2.3 Economic implications of the future ageing population	7
3. RESPONDING TO THE CHALLENGE THROUGH TECHNOLOGY	11
3.1 The concept of ageing-in-place	11
3.2 Developing a broader response through converging or enabling technologies	13
4. OVERSEAS STUDIES OF TECHNOLOGY USE IN THE DAILY LIFE OF THE ELDERLY	17
4.1 Opportunities identified in overseas studies	17
4.2 Elderly-friendly housing	20
5. TECHNOLOGICAL OPPORTUNITY AREAS IN AGED CARE FOR AUSTRALIA	23
5.1 Identification of opportunities for gerontechnology in Australia	23
5.2 Security and safety	24
5.3 Diagnosis and treatment	26
5.4 Assistive technologies	31
6. SOCIAL AND ETHICAL ISSUES IN THE APPLICATION OF TECHNOLOGIES FOR ELDERLY PEOPLE	37
7. CONCLUSIONS	41
8. ABBREVIATIONS AND ACRONYMS	45
9. REFERENCES	47
APPENDIX A	53
Outputs from the ATSE questionnaire and workshops	
APPENDIX B	59
Visits and discussions associated with the study	

APPENDIX C

61

Programme for EU/Australia workshop on 'Smart Technology for Healthy Longevity',
Paris, October 2009

ATTACHMENT

65

Economic analysis: report prepared by Centre for Strategic Economic Studies,
Victoria University, Melbourne

1 Background, Aim and Scope of this Study

“Human beings are extremely complex. Despite centuries of study, our depth of understanding about older people is still rudimentary.”

– Rory A. Cooper, NAE, 2009

Each year the Australian Research Council invites bids from the four Learned Academies in Australia to propose projects for funding under the Linkage Learned Academies Special Projects (LASP) scheme. Such projects utilise the expertise of Fellows of the Academies in broad-ranging topics relevant to Australia.

In 2008 ATSE was awarded a LASP grant on the potential for the application of converging technologies in illness and wellness in Australia. The aim of that project was to bring together researchers and practitioners in nanotechnology, biotechnology, information technology and cognitive science to examine new ways of dealing with growing health problems in Australia. Professor Greg Tegart AM FTSE was appointed Principal Lead Investigator with Professors Peter Hudson FTSE and Terry Turney FTSE as Lead Investigators. A Steering Committee was established consisting of Academy Fellows and external experts.

At its initial meeting the Steering Committee decided that the proposed scope of the project was too broad for the funding provided and should be concentrated on technologies for the ageing, particularly the issue of ageing-in-place, as the ageing population is seen to present a major problem in future provision of health services in Australia.

A questionnaire was circulated to ATSE Fellows in early 2009 and the responses are summarised in Appendix A. A short review paper was prepared as the basis for workshops held in Brisbane, Melbourne and Sydney. Each was attended by 20 to 25 Fellows and invitees. The outcomes of these workshops are summarised in Appendix A.

Visits were made to researchers and practitioners in those cities and also in Canberra in the course of the study (see details in Appendix B). The material gathered in these visits has been supported by an extensive literature survey.

Further input has been provided by discussions at the Annual Conference of the Health Informatics Society of Australia in Canberra in August, 2009 where Professor Tegart presented a paper on the ATSE study in a symposium on ageing. The issue of national electronic health records was a major focus of the meeting.

Another important input was provided by presentations made at an EU/Australia workshop on Smart Technology for Healthy Longevity in Paris on 5 and 6 October 2009 and discussions with French

researchers in the following days. ATSE was awarded a grant by the Department of Innovation, Industry, Science and Research to enable a Delegation of 12 Australians to participate in the workshop and visits. The delegation, which was led by Professor Tegart, included Professor Peter Hudson and Professor John Weckert (both associated with the present study). Appendix C lists the program of the workshop.

A further valuable input came from the presentations at an ATSE NSW Divisional seminar on “Impact of Disruptive Technologies on Healthcare in Australia” on 7 October 2009 organised by Mr Keith Daniel FTSE, a member of the Steering Committee. These can be viewed at www.atse.org.au/resource-centre/ATSE-Reports/HealthTechnologies. Several related articles appear in ATSE *Focus*, No. 160, February 2010 – see www.atse.org.au/resource-centre/focus/2010-Issues.

One component of this study is a review of the economic benefits of interventions to enable more people to age at home and of the potential savings to the Australian Government. This review was carried out by Dr Kim Sweeney of the Centre for Strategic Economic Studies, Victoria University, Melbourne. It is provided as an attachment to this report.

2 The Challenge of an Ageing Society in Australia

2.1 CHANGING DEMOGRAPHICS

All industrialised and many developing countries are experiencing a demographic transition from predominantly younger populations to a much larger proportion of old people. This has resulted from a decrease in fertility rate due to societal changes coupled with an increase in life expectancy due to better diet and healthcare. The rate at which this transition is occurring varies from country to country depending largely on fertility rate and rate of immigration. Thus the change is more rapid in countries with little or no immigration than in countries with a vigorous immigration program.

The driver of economic growth in countries is the group in the population aged 25 to 54 years, which provides the workforce to service growth and the spending to sustain domestic demand. The demographic transition can be characterised by examining the change in the prime age population (the cohort of the workforce aged 25 to 54 years) over time and estimating when it will peak or, in some cases, has peaked. As an illustration, data for some Asia–Pacific economies are given in Table 1.

Table 1 Peak year for prime age population in selected Asia-Pacific economies (LSIF 2008)

Economy	Year (approximately)
Japan	2000
Singapore	2005
Korea	2010
China	2015
Indonesia	2035
Vietnam	2035
Australia	2050 (no peak)
USA	2050 (no peak)

These figures show the influence of migration and social pressures. Thus Japan and Korea are relatively closed societies with little or no immigration, Singapore has limited land area and all three have peaked. China has a one-child policy and will peak soon but still has a large rural population on which to draw for workers. Neither Indonesia nor Vietnam has moved to reduce their population growth rates and their prime age populations will continue to grow until about 2035. Both the USA and Australia have experienced high levels of immigration and this has bolstered their population growth rates. Although their prime age populations will decline as a proportion of total population, in absolute terms they will continue to increase at least until 2050.

Because population growth in Australia is driven by the two inputs of natural growth (births minus deaths) and migration from overseas, demographic behaviour is strongly influenced by the contemporary economic and social situation. When the economy is unfavourable, births are delayed and migration falls. When the economy is strong, birth rates rise and new migrants are attracted. Thus estimates of future demography need be linked to argued positions of future economic and social trends. An example is a projection based on the premise that, in broad terms, the Australian economy will be strong across coming decades with the sustained economic growth of China and India underwriting continued growth of the Australian economy (ATSE 2007). The likely domestic implications of this are substantial

increases in standard of living, major investment in new physical infrastructure, a considerable demand for labour, substantial new investments in education and training, and changes in social institutions to ensure equity. Despite the recent global financial crisis, the indications are that this scenario is still valid.

Against this background, with some assumptions on labour supply, fertility, migration, mortality and labour force participation rates, the projection in Table 2 was produced. These projections show the total population growing by about one per cent per year.

Table 2 A population projection for Australia (ATSE 2007)

	2010	2020	2030	2040	2050
Population (million)	21.5	23.8	26.3	28.7	31.2
Aged 65+ (%)	14.2	17.6	20.5	21.7	21.6
Labour force (million)	11.1	12.2	13.1	14.1	15.4

Other projections have been made for the population of Australia (Productivity Commission 2005; Treasury 2007). While these differ in detail depending on the input assumptions, the numbers have been generally similar, with a continued increase in population coupled with a more rapid increase in the proportion of elderly people. Table 3 gives another projection (Vos et al. 2003), which shows how the 'older old' will increase significantly over the next decades. The outcome of these projections is a change in the demographic structure from a 'pyramid' in 1971 to a 'coffin' shape by 2041 with progressive convergence on a new equilibrium profile rather than indefinite ageing of the population.

Table 3 An aged population projection for Australia (Vos et al. 2003)

	2003	2013	2023	2033
Population (million)	19.9	22.2	24.5	26.6
Aged 65+ (%)	11.3	13.3	17.0	19.5
Aged 85+ (%)	1.5	2.2	2.8	4.6

The issues raised by such projections for the future aged population were addressed by the Australian Government in 2002 in the National Strategy for An Ageing Australia (see www.longevity-international.com), which focused on four main economic and social themes:

- independence and self-provision;
- attitude, lifestyle and community support;
- healthy ageing; and
- world class care.

Goals and actions were outlined for each of these to bring together Australian and State Governments, business and communities. The Strategy was couched in general terms and raised a number of issues linked to technology such as improved infrastructure in housing and public and private transport, user-friendly design, innovation in healthcare delivery, opportunities for cost reduction in health care, use of the Internet and informed choices in healthcare.

Further to this there has been the development of an Australian Ageing Research Agenda (see www.aro.gov.au/documents/FAARA) which has two main categories of issues:

- Strategic Priorities for Building ageing Research Capacity – dealing with research infrastructure, practices and processes.
- Strategic Ageing Research Themes – dealing with research subject matter and themes.

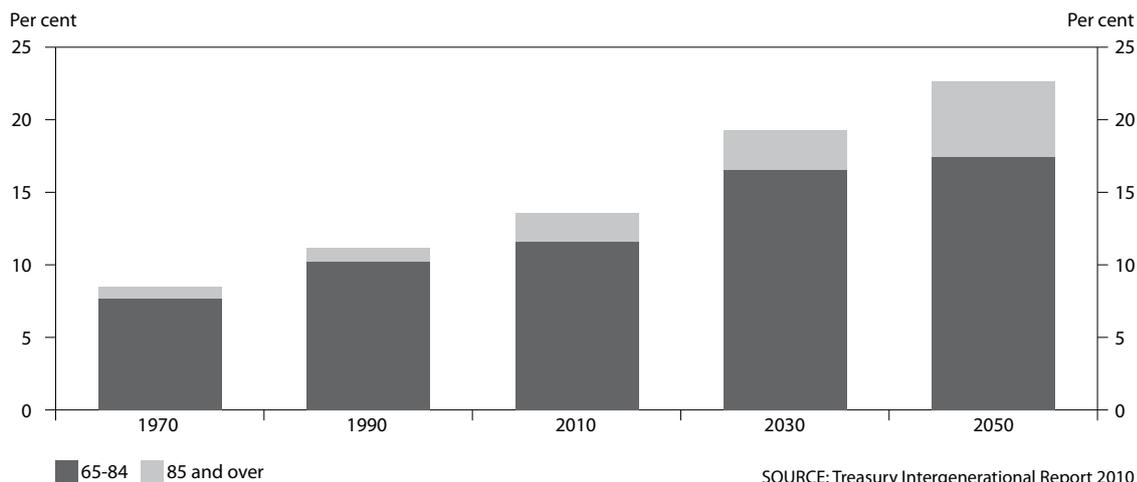
The main thrust of the Research Agenda is to produce social and economic research to support policy development. An important outcome has been the Ageing Well Research Network

(see www.ageingwell.edu.au), which has been operating through State hubs and building databases in four areas:

- productivity and economic security;
- independent living and social participation;
- healthy ageing; and
- population research strategies.

Recently the population projections for Australia have been revised upwards in a new Intergenerational Report (Treasury 2010) which projects that Australia's population will grow by 65 per cent to reach 35.9 million by 2050. The increase is anticipated to be driven by a greater number of women of childbearing age, higher fertility rates, and increased net overseas migration. At that time the proportion of the population aged 65 and over is projected to rise to 22 per cent (7.9 million) while the proportion aged 85 and over is projected to rise to five per cent (1.8 million) as shown in Figure 1. This increase is against a background of reduction in the number of working age people, with only 2.7 people of working age to support each Australian aged 65 years and over by 2050, compared to five working-aged people per aged person today and 7.5 in 1970.

Figure 1 Proportion of the Australian population aged 65+. Ageing is a challenge for future economic growth; the proportion of the population aged 65+ years is increasing



Similar demographic changes are occurring in all developed nations and an increasing number of developing countries, leading to increasing recognition of the potential of new technologies to support and improve health and social care services and to enhance the independence and quality of life of older people. Australia has been slower to recognise this potential than in Europe and the USA and there is little recognition of this as a policy issue even in the latest Intergenerational Report when compared to reports from, say, the UK (Ageing Population Panel 2000, Sixsmith 2002).

2.2 HEALTH AND SOCIAL IMPLICATIONS OF THE FUTURE AGEING POPULATION

On the one hand, the increasing numbers of older people constitute a resource of talents, skills and experience, which can be of great benefit to society if their years of healthy life can be extended (PMSEIC 2003). On the other hand there will inevitably be a significant increase in the numbers of aged people to be cared for in the future. This increase will occur against a projected fall in the number of working age people able to support the aged population. Various reports have projected impending major shortfalls in all medical professionals and carers, and the need for a new policy framework (Ilfie 2007).

An inevitable consequence of increased age is the progressive decline in the functional capacity of organs and muscles. However there is a wide variation in the rate of decline at various ages (AIHW 2008). Although the percentage of people aged 65 and over is increasing, it is the oldest old, the 85 plus, that is the growing cohort. These are the frailest, with the highest incidence of diseases and disability. Thus in 2003 while about 21 per cent of the Australian population aged 65 and over had a profound or severe disability, the proportion increased to 65 per cent for persons aged 85 or above. Given that healthcare costs per capita escalate rapidly above 45, doubling between 45 and 65 and then doubling again between 65 and 85, these groups represent an increasing cost to society, as noted in the Intergenerational Report (Treasury 2010).

Australians born today can expect to live more than 20 years longer than they did a century ago. At the beginning of the 20th century, major killers were infectious diseases, diseases of early childhood and maternal morbidity. By mid-century the major killer was cardiovascular disease, in which great advances in treatment have been made in recent decades. As we enter the 21st century, chronic diseases of ageing have become growing sources of morbidity for Australians. The burden of disease and disability can be broken down into cancers (19 per cent), cardiovascular disease (17 per cent), mental disorders (13 per cent), neurological and sense diseases 13 per cent) and chronic respiratory diseases (seven per cent) (AIHW 2008).

As emphasised in a report from the Prime Minister's Science, Engineering and Innovation Council several years ago, there are adverse trends in Australia in factors causing chronic disease that will undermine the health gains of recent years, particularly in heart disease mortality (PMSEIC 2003). Dramatically rising rates of obesity and diabetes, mainly due to poor diet and physical inactivity, will have a serious long-term impact on health and health care costs. Healthy ageing needs to be based on a whole-of-life approach. PMSEIC recommended "that a national strategy be developed aimed at increasing levels of physical activity among older Australians so that the health, social and economic effects of physical activity are made available to all older Australians".

The pattern of disabilities is important when considering technologies to maintain a high quality of life for aged people. An analysis of selected disabling conditions across the lifespan using 1998 data showed that the main conditions associated with profound or severe core activity restrictions in Australians aged 65 years and over were musculoskeletal, nervous system, circulatory and respiratory conditions, and strokes (Giles et al 2003). Among those with mild to moderate restriction, musculoskeletal, circulatory, respiratory, hearing and vision-related conditions are common. Projections indicate that the absolute numbers of people aged under 64 with some form of disability will rise only slightly, while for those over 64 the projected numbers will be increased significantly. Thus the number of older people with profound disability is estimated to nearly double from 2006 to 2031.

It is also important to recognise the environment in which the demographic changes will take place. Thus, in the timeframes of the projections above, settlement patterns in Australia are not expected to change much with the growth of population absorbed within the existing patterns of settlement so that Australia remains an essentially urban society with perhaps four major agglomerations: Sydney/Hunter/Illawarra; Melbourne/Barwon/Central Tablelands/Loddon; south-east Queensland; and Perth/Peel/south-west. Some rural cities could be expanded and will need advanced medical facilities (ATSE 2007).

There will be a need for new approaches to housing, urban planning and transport to cope with the projected increase in the aged population. A recent report suggests that about 6.9 million new homes will be needed by 2050 to cope with the overall population increase (Bibby 2010). There is a need to urgently consider how the Building Code of Australia and associated Standards will need to be changed to cope with such increased urban expansion coupled with the desire of old people to live in their own homes with improved services and enhanced levels of safety and security (Donaldson 2009).

Further, major changes in climate could impact strongly on the aged in these agglomerations through increased frequency of extreme temperatures with increased heat-related deaths due to heat stress and increased air pollution in cities. Currently about 1000 deaths per year are heat-related in origin and this is projected to double in the next decades (Rose 2009). In addition, increased natural disasters (droughts and flooding) could lead to dislocations in food supply and land transport, while continued southward spread of vector-borne diseases already endemic in northern Australia will lead to more pressure on health services. Emerging infectious diseases such as SARS, avian influenza and swine influenza, which can be rapidly transmitted on a global basis, could have serious impacts on the elderly cohort with lower resistance to infection.

2.3 ECONOMIC IMPLICATIONS OF THE FUTURE AGEING POPULATION

Healthcare costs have been rising in most countries. A measure commonly used to describe the relative sizes of health systems in different countries is their expenditure on health expressed as a percentage of Gross Domestic Product (GDP). The estimated total expenditure on health (excluding high-level aged care, which is considered a welfare service) in Australia in 2005-06 was roughly \$87 billion or nine per cent of GDP (about the median of OECD countries). A decade earlier, expenditure on health was 7.5 per cent of GDP. In 2005-06, this expenditure was funded by contributions from the Australian Government (3.9 per cent of GDP), state/territory and local governments (2.3 per cent of GDP) and non-government sources – health insurance funds, private individuals and other compensation funds (2.8 per cent of GDP) (AIHW 2008).

In itself, ageing has been historically a relatively minor driver of rising health costs. Non-demographic factors, particularly increasing utilisation of services and the use of new and expensive technologies, have been the major source of rising health expenditure over the past 20 years. Real per capita spending has been increasing for all major components of government health expenditure. This has arisen because rising incomes, while providing the capacity for increased government funding of health care, have created greater expectations of better treatments and investment in new health technologies to improve and prolong people's lives. However, since older people use more health services, the impact of costs arising from demand and new health technologies is further amplified by a greater proportion of aged in the population.

The projected increase in the ageing population with a trend towards higher cost medical interventions means that healthcare costs will continue to rise for several decades. This trend and its likely implications have been examined by the Australian government in recent years. Thus in 2003 there was a review which addressed the issues of pricing and funding residential care (Aged Care Price Review Taskforce 2003). This was followed by a major review of the economic implications of an ageing Australia (Productivity Commission 2005). Detailed modelling of demographic, economic and related trends in relation to budgetary implications was carried out in the Second Intergenerational Report (Treasury 2007). The Productivity Commission then used these data in another report on aged care services (Productivity Commission 2008). A study in 2008 estimated that total health expenditure will increase by 127 per cent in the three decades between 2002-03 and 2032-33, from \$71 billion to \$162 billion (constant prices). However GDP was predicted to rise over that period by 97 per cent, so that total national expenditure on health care in 2032-33 will be about 10.8 per cent of GDP (AIHW 2008).

Most recently the 2010 Intergenerational Report (Treasury 2010) projects that ageing and health pressures will lead to slowing economic growth coupled with an increase in Australian Government spending. Thus healthcare spending by the Australian Government is projected to grow from 4.0 per cent of GDP in 2009-10 to 7.1 per cent of GDP in 2049-50. Further, spending for high-level residential aged

care is projected to grow from 0.8 per cent to 1.8 percent for the same period with age-related pensions growing from 2.7 per cent to 3.9 per cent. Despite concerns expressed in the Australian Government studies that there could be fiscal problems in the future, there is an optimistic view that these costs can be accommodated by continued economic growth (for example, Doughney 2008). The importance of enhanced productivity growth as the key to maintaining economic growth is reinforced in the 2010 Intergenerational Report (Treasury 2010).

Nevertheless, there is a need to examine the detail of the expenditure to see where savings can be made. A projection for 2032 shows that medical expenditure will increase by about 100 per cent, with major increases in costs of diabetes, neurological disorders, musculoskeletal conditions and dental services (AIHW 2008). Much of the expenditure is associated with the aged but new medical advances coupled with improved lifestyles and elderly-friendly housing offer possible cost reductions.

In particular, residential aged care (high care) is projected to show the greatest growth with a major contributor being dementia in the oldest old and the increased need for carers. In older people dementia is more likely than other health conditions to be associated with profound limitations in self-care, mobility and communication, and with multiple health problems. Consequently the proportion of people in residential aged care increases rapidly with age to a quarter of all persons over 85 in residential aged care.

The cost of residential care in 2006-07 has been estimated at \$33,000 per annum and the average duration of stay at 146 weeks (ACIL Tasman 2009). Reducing the cost of residential aged care through ageing-in-place is clearly a priority area. The review prepared for this study by the Centre for Strategic Economic Studies (see Attachment) indicates that substantial savings are possible with only a small proportion of the residential aged care population staying in the community. Thus, if only 10 per cent of the current residential care group could stay in the community through application of an 'ageing-in-place' policy supported by appropriate technologies and receipt of Home and Community Care rather than residential aged care, this could save the Government about \$526 million per year. Future savings could be even greater.

Further, as noted in the Attachment, another identifiable saving is in the reduction of accidental falls through the application of suitable technologies. If only 10 per cent of falls could be avoided, the cost of such injuries would be reduced by about \$85 million per year. These figures are conservative and a more detailed study for Australia is needed to define the economic benefits more clearly. Overseas data for telehealth applications claim much better reductions in admissions to hospitals, numbers of home visits and visits to general practitioners (Celler 2009).

Apart from the quantifiable benefits of using smart technology to reduce the cost of health care to government, there are less easily quantifiable benefits associated with the standard of social services and the quality of life for older people that result from improved services and enhanced security and safety. The Royal Commission for Long Term Care was set up in the UK in 1997 to examine options for a sustainable system for funding care for older people. In emphasizing the role of technology as a major option for improving quality of life it said (see www.royal-commission-elderly.gov.uk): "One of the ways in which life could improve for older people is the harnessing of new technology in new, imaginative and profitable ways. Such use of technology will enable older people to be cared for more easily so that they feel secure in their communities without the need for other more expensive interventions."

Finally, while most of the discussion here has focused on healthcare costs, it is essential to recognise that the projected changes in demographic patterns present a challenge to Australian business, which needs to alter its outdated stereotypes about older customers. Consumer demands will increasingly be driven by the tastes and needs of older people. These will range from leisure to education, from health to

financial services. Older people in future will be more accepting of technological aids and interventions and will seek to be involved in the design of new systems and devices. With the increasing number of frail old affected by varying disabilities and functional impairment, there is a clear market opportunity, both domestic and international, for products and services that cater to their requirements. It is important to recognise that many of these solutions based on technology are likely to be of benefit to the rest of the population as well as providing the basis for new products for export.

SMART TECHNOLOGY FOR HEALTHY LONGEVITY

3 Responding to the Challenge Through Technology

3.1 THE CONCEPT OF AGEING-IN-PLACE

There is a variety of living environments to which people may progressively move as they age. The so-called ‘continuum of care’ is: home, independent apartment living, assisted living facility, skilled nursing facility, and 24 hour care unit. Each move along the continuum escalates the cost of care and may alter quality of life. Although some downsize or move into an aged care facility, more than 80 per cent of people aged 65 and over live independently. Of these some 40 to 50 per cent are estimated to live in lone-person households. The desire to maintain independence in one’s own home (ageing-in-place) is routinely identified as a passionate priority by people as they age. Apart from maintaining quality of life, ageing-in-place provides economic benefits to society as a whole by reducing the public resources devoted to aged care.

The various combinations of frailty, disease and disability can place a considerable burden on the capacity of individuals to live independently. Carers and family members who provide informal care are constantly seeking solutions to help maintain the elderly in safety and comfort in their own homes. Technology can be applied in a variety of ways in response to the decline associated with ageing – monitoring the rate of decline, slowing the decline and providing assistance at a given level of decline.

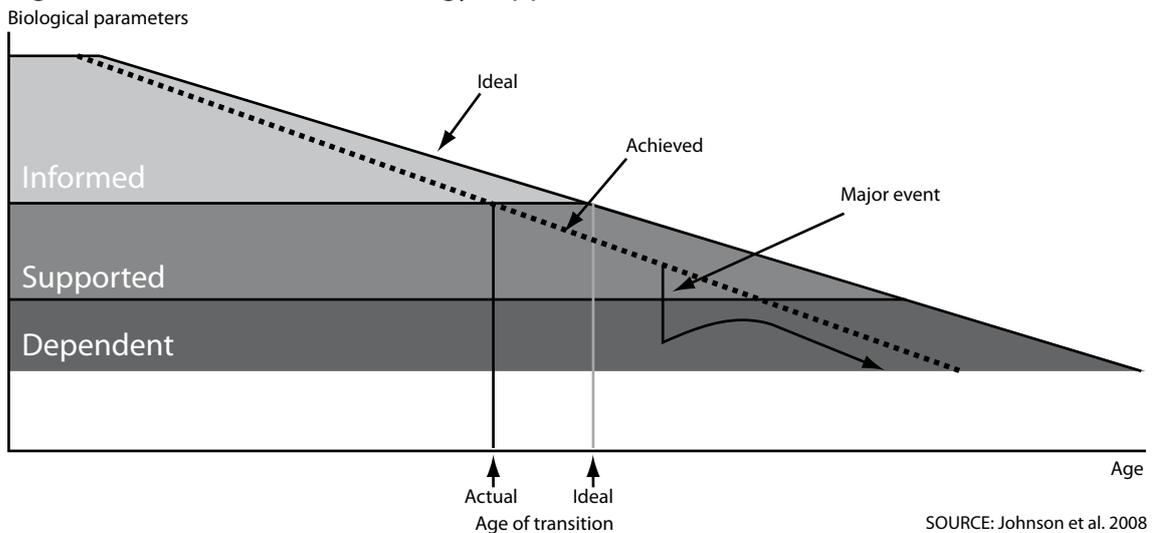
A very useful framework for application of technology has been suggested that uses biological parameters to establish, on a personal level, safe boundaries for a variety of physiological variables (Johnson et al. 2008). In Figure 2, the ideal (best outlook) biological process is shown. As the level of relevant biological and physical measures declines, there is a transition through the “three stages of ageing”:

1. Informed – where there is a potential major benefit from controlling lifestyle.
2. Supported – where there is a need to use appropriate technologies to maximise independence.
3. Dependent – where independence relies upon the proactive support of technology.

Figure 2 also shows the impact of a major trauma such as a severe fall or a stroke, accelerating the transition to dependent status and then a possible improvement with rehabilitation. The illustrated trajectory suggests that the ‘supported’ stage is unlikely to be reached again.

These stages map across the continuum-of-care concept noted earlier, with emphasis on the earlier stages and ageing-in-place. The European Commission-funded MOBILATE project examined how technology-based options could simplify life at home for elderly people (Ruoppila et al. 2003). The most useful needs listed were relatively simple, for example automated lighting in entrance areas, automated heating regulation, and motion detection in hallways. Technology for most of these is already on the market and being introduced into ‘smart homes’. More interesting were the responses to activities perceived to be difficult, for example hanging curtains, fixing household devices, cleaning windows, ironing, and making the bed. These present challenges for technological solutions.

Figure 2 Boundaries of technology support



There is a very large output of reports and papers aimed at providing technological solutions for the support of an ageing society at home. A wide range of products already exists in categories such as (Bouma et al. 2009):

- safety and security – fall detection, mobility aids, smoke monitors, door locks;
- treatment – monitoring, telemedicine, health medication compliance;
- social connectedness – mobile phones, video and email; and
- mobility – warning systems for older drivers, safer transport vehicles.

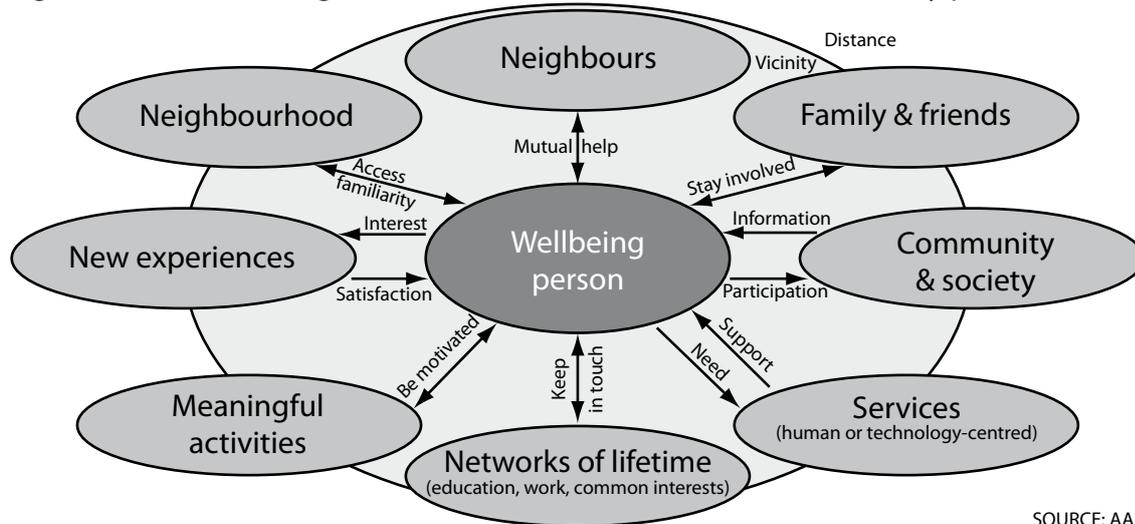
However, despite the availability and general affordability of these products, market penetration is small within the existing cohort of elderly people. There appear to be several factors contributing to this situation, including the ways in which user needs and markets have been defined and how services are currently delivered to the home.

It is important to recognise that there is no single target group for products and services for the aged population. Sharing a chronological age does not make for homogeneity. In fact, there is greater heterogeneity than in younger groups, due to the range of life experiences, exposure to diseases and differences in lifestyle. In considering the needs of the ageing population, it is important to recognise the complex environment in which they live and the differing character of their interactions within that environment (Figure 3). Technology probably has the strongest inputs in the contexts of Services, Community and Society, and Family and Friends, but communication is involved in all of the sectors. There has been little recognition of the existence of multiple and complementary markets, which include family caregivers managing chronic diseases, ageing baby boomers managing health and wellness (often called the worried well) and older adults seeking to ensure their ability to age-in-place.

A significant factor in product acceptance is the cultural background of the elderly cohort. Lower-skilled workers and elderly migrants have problems in purchasing and coping with complex technologies. These markets will change as the next generations of more skilled and technologically literate people move through and wish to continue working or contributing to society. They will significantly enhance the ageing cohort – a man aged 60 can expect about 22 years of retirement and a woman of the same age about 26 years. These generations are likely to have greater disposable incomes than the present aged generation and more likely to embrace technological interventions.

Services have been delivered through a variety of products that are not compatible with each other in the home environment and have not incorporated recognition of user needs. Benefits from technology must

Figure 3 Schematic diagram of the social interaction context of elderly persons



SOURCE: AAL

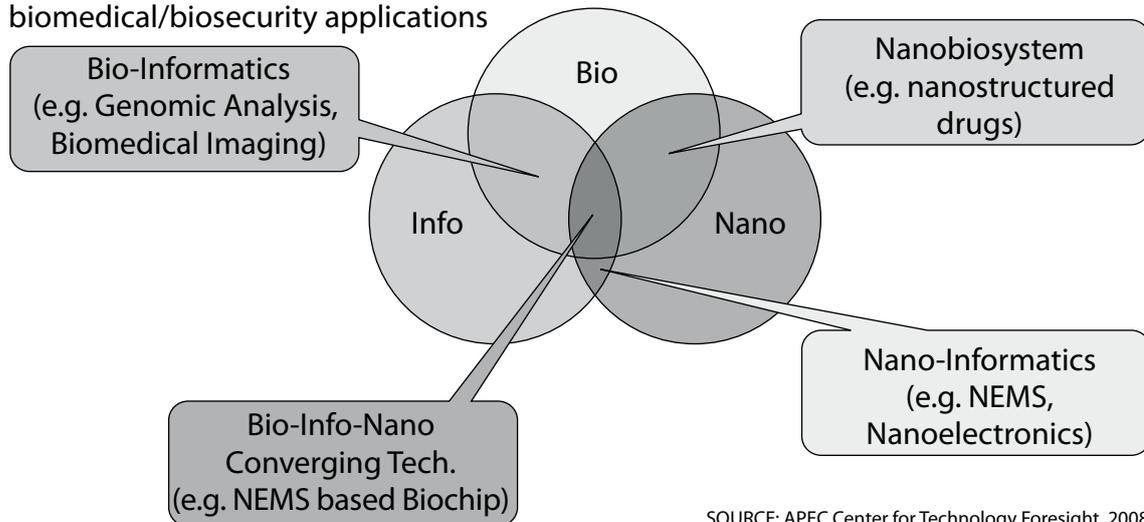
outweigh the drawbacks inherent in life with any ‘gadget’. Many ingenious products fail because they do not satisfy this criterion. Thus products often seem to be designed with the maintenance contractors as the customer. Many consumer products are constantly re-engineered and redesigned with no obvious added functionality but with poorer interfaces for older people, for example mobile phones with reduced key size and more confusing icons and sub-menus. While so-called ‘smart homes’ are already being built in small numbers, the general need is for solutions which are able to be retro-fitted into current homes while offering reliable and fault-tolerant services that can be easily managed by the user, for example simple dials instead of complex buttons and readouts. Human-centred design needs to pay attention to all these factors as they relate to technical function and form. The involvement of aged people both in the definition of function and design, and in feedback on acceptance and performance is vital in the development process.

3.2 DEVELOPING A BROADER RESPONSE THROUGH CONVERGING OR ENABLING TECHNOLOGIES

While traditional disciplines have been used together in the past, the concept of ‘converging technologies’ has been developed in the USA to describe the combination of new technologies such as nanotechnology, information and communication technologies and biotechnology in applications for human health and wellbeing (Roco and Bainbridge 2003). The inclusion of cognitive science is seen as providing an additional input in new approaches to difficult areas such as brain-machine interfaces and dementia (Bainbridge and Roco 2006). The term NBIC has been used to describe this combination of nano-bio-info-cogno. This US view of convergence promises to transform every aspect of life but has raised alarms about ambitions to ‘improve human performance’ by ‘turning humans into machines’.

Another view has been taken in Europe where converging technologies are defined as ‘enabling technologies and knowledge systems that enable each other in pursuit of a common goal’ (Nordmann 2004). In this approach, nanotechnology, biotechnology and information technology (and to some extent cognitive sciences) are seen as framework or enabling technologies that can jointly contribute towards solutions. In this spirit the potential of converging technologies for developing active ageing policy has been explored in Europe (Compano et al. 2006). This concept of converging technologies have been used in the Asia-Pacific region to tackle complex health issues such as DNA analysis for human health in the post-genomic era (APEC CTF 2003), emerging infectious diseases in the Asia-Pacific region (APEC CTF 2008) and biosecurity in Australia (Tegart and Prowse 2008).

Figure 4 An example of convergence of technologies in biomedical/biosecurity applications



SOURCE: APEC Center for Technology Foresight, 2008

An illustration of the convergence of nanotechnology, biotechnology and information technology is given in Figure 4, in the context of biomedical/biosecurity applications. Overlaps occur between all of these to produce new fields of interest.

A more complex diagram linking a number of technologies has been produced to show applications of technology in ageing (Compano et al. 2006). These authors use their approach to list a large number of potential applications such as artificial molecular muscles, biosensors, gene therapy, intelligent drug delivery, rationally designed drugs, biocompatible materials, prosthetic vision and advanced robotics, where convergence could make major advances possible.

The concept of enabling technologies has been taken up by the Australian Government in its recent National Enabling Technologies Strategy (see www.innovation.gov.au/nets). The Strategy will “focus primarily on nanotechnology and biotechnology and will also undertake strategic assessment of the development of new enabling technologies and the convergence of new and existing technologies”. The Strategy will deal with ICT to the extent that it is an enabler for and/or converges with nanotechnology, biotechnology and other enabling technologies. The aim is to work with a range of stakeholders including industry, governments, non-government organisations, research organisations and universities. Funding of \$38.2 million is to be provided over four years to support the Strategy. Of this, \$10.6 million is to support policy and regulatory development, industry uptake, international engagement and strategic research; \$9.4 million is for public awareness and community engagement to increase understanding of enabling technologies; and \$18.2 million is for the National Measurement Laboratory to improve measurement infrastructure, standards and expertise.

The term gerontechnology was coined in Europe in 1989 to describe the combination of medical aspects of ageing (gerontology) with technology to assist daily living. Gerontechnology matches technological environments to the health, housing, mobility, communication, leisure and work of older people and aims at promoting human health and wellbeing. It drew initially on the field of assistive technologies, which emerged from the linkage of engineering and biomedical specialists to produce rehabilitation engineers able to assist people with disabilities and impairments. Increasingly it is linking to gerontology and geriatrics as an essential component of coping with an ageing society. The International Society for Gerontechnology is a major international body with a significant journal and regular world conferences (Bouma et al. 2009).

Gerontechnology fits well with several of Australia's National Research Priorities and their Associated Priority Goals (see for example www.innovation.gov.au/Section/AboutDIISR/FactSheets/Pages/NationalResearchPrioritiesFactSheet.aspx, as follows:

- Promoting and Maintaining Good Health, Goal 2: Ageing well, ageing productively – developing better social, medical and population health strategies to improve the mental and physical capacities of ageing people.
- Frontier Technologies for Building and Transforming Australian Industries, Goal 2: Frontier Technologies – enhanced capacity in frontier technologies to power world-class industries of the future and build on Australia's strengths in research and innovation (examples include nanotechnology, biotechnology, ICT, photonics, genomics/phenomics, and complex systems); Goal 3: Advanced materials – advanced materials for applications in construction, communications, transport, agriculture and medicine (examples include ceramics, organics, biomaterials, smart materials and fabrics, composites, polymers and light metals); and Goal 5: Promoting an innovative culture and economy – maximising Australia's creative and technological capability by understanding the factors conducive to innovation and its acceptance.

Other technical terms are also used in this field. 'Assistive technology' can be defined as 'an umbrella term for any device or system which allows an individual to perform a task they would otherwise be unable to do or increase the ease and safety with which the task can be performed'. This field is being strongly supported in Europe (in the UK, the Royal Academy of Engineering (RAE) supports the UK Focus for Biomedical Engineering), in the USA and in Australia, by engineers involved via the National Committee on Rehabilitation Engineering of Engineers Australia. It clearly has a special relevance for the frail elderly. The term 'assistive domotics' is sometimes used to describe a form of home automation devoted to applying assistive technologies in the home.

The growing importance of the application of technology to ageing has stimulated engineering academies and professional engineering bodies in various countries to produce reports detailing approaches and priority areas of research applicable to their situations (RAE 2008, NATF 2008, Engineers Australia 2008, acatech 2009, NAE 2009). All call for greater government recognition of the impact of the ageing population on their societies and for increased support of development and application of technologies to provide solutions. An EU/Australia Workshop in Paris in October 2009 brought together a number of experts from five European engineering academies (France, Germany, UK, the Netherlands, Czech Republic) to exchange experiences with a delegation of Australian experts organised by ATSE (see Appendix B). The discussions highlighted the commonality of the demographic changes in countries, the scale of the technological response in Europe, the social dimensions of the challenge of ageing, the importance of user-centred design, developments in elderly-friendly homes in Europe, the role of interdisciplinarity in the development of a discipline of gerontechnology, clustering for innovation in Europe, need for new models of care and assessment of quality of research.

SMART TECHNOLOGY FOR HEALTHY LONGEVITY

4 Overseas Studies of Technology Use in the Daily Life of the Elderly

4.1 OPPORTUNITIES IDENTIFIED IN OVERSEAS STUDIES

Several approaches have been used in developed countries in considering opportunities for technology use in the daily life of the elderly. Some look to technology simply to monitor health and disease state, but others have taken a broader view of technologies to support living at home (home care; safety, security and privacy; supply of goods and services) and its surroundings (working life; mobility; social interaction; information and learning; health and wellness). Such technologies can be used by seniors, by caregivers (both professional and informal), by healthcare providers and by ageing-services providers. These technologies depend strongly on information technology to support assistive systems such as telemonitoring, telehealth, telemedicine, and communication devices that improve social interaction.

The French Academy of Technologies has considered the elderly as a subset of the general populace in their report on ambulatory medicine, which describes how patients can access medical and health care with similar standards to those in hospitals while remaining at home or continuing normal activities (NATF 2008). Their particular concern is chronic diseases, which are a growing problem among the aged. The driving force is information – its collection, transmission and utilisation. Collection of data for the aged could be achieved through sensors in ‘smart clothes’, in ‘smart homes’ and in bracelets. These data need to be transmitted to a central point where physicians can use them to follow the health of a person and take appropriate action when they see a need for intervention such as medication or hospitalisation.

Similar health monitoring technologies are included in a US assessment of the state of technology in ageing services (Alwyn et al. 2007). That report considers various themes:

- safety – fall detection and prevention technologies such as mobility aids, stove use detectors, smoke and temperature detectors, door locks, wander management systems;
- health and wellness – telemedicine and telehealth; medication compliance technologies; cognition assessment; and
- social connectedness – video and mobile phones, email.

The benefits and cost issues of these technologies are examined and the authors emphasise that their successful application is dependent on organisational changes, innovative business strategies and human capital.

In another broad approach to health care in the USA (Coughlin and Pope 2008) the uses of information in the home are considered under three headings:

- monitor – for ensuring wellbeing;
- manage – for efficient use of the resources available; and
- motivate – to encourage preventative behaviour.

Table 4 Technology use in home healthcare and disease management (Coughlin and Pope 2008)

	Function	Selected technologies	Innovation & outcomes
Monitor	24/7 monitoring of health and activities	Intelligent devices and appliances, robotics internet-enabled services, predictive behaviour models, etc	Reduction of emergency events, rapid intervention to health changes, and/or decline
Manage	Identify and prioritise patients requiring remote or home-based intervention	Information technology and software with embedded risk models to triage, review and assess patient progress	Efficient use of home health care, human and financial services
Motivate	Engage, educate and empower patient and/or family in their own health	Glanceable display technologies, two-way communications, integration of fun and familiar entertainment systems to coach and connect patients, caregivers, families	Management of existing conditions and prevention of disease

Possible technologies are shown in Table 4. Many, if not all, of these technologies provide the basis of telemedicine or telecare to support the health, wellness and disease management needs of older adults and caregivers at a distance from major medical centres.

In the UK the concept of informed, supported and dependent stages of ageing has been used to develop technology needs for an ageing population (Johnson et al. 2008). As shown in Table 5, a number of possible devices and technologies have been identified for these three stages of ageing. In the first two stages, personal devices are dominant but the third, dependent, stage strongly involves the home environment.

Another approach in the UK has been to identify possible technologies linked to three key themes of later life, namely, wellbeing, mobility and community (Cels 2007). Wellbeing covers a number of topics: ■ personal healthcare, to maximise the opportunity for people to manage their own health by providing fast and reliable readings on key metrics such as spirometry, blood pressure and weight and body mass index;

Table 5 Major technology needs to support the three stages of an ageing population (Johnson et al. 2008)

	Devices	Technology
Informed – Feedback of relevant physiological parameters	– Measurement devices and transducers – Wearable devices – IT systems NB In this phase it is very important that solutions are unobtrusive and take little effort and/or time.	– Sensors – New materials – Data logging and IT – Pervasive computing – Technologies that assist in motivating people to comply with recommendations and guidelines
Supported – Biomechanical – Sensory – Mobility – Rehabilitation – Safety and security	– Total joint replacement – Orthoses – Incontinence support (clothing and devices) – Sensory devices – vision, hearing etc. – Interactive devices	– Materials – Fundamental studies – Sensors – Advanced robotics NB This is when inclusive design is most important to lower the barrier of stigma
Dependent – Safety critical monitoring – Safety and security – Communications – Rehabilitation	– Smart homes – Intelligent systems – Advanced mobility devices – Haptic devices	– Sensors – Pervasive computing – Surveillance systems – Advanced robotics

- medication compliance, to remind people to take their correct medication at the correct time and maintenance of health by transmitting personal data to a control centre for monitoring by nurses to detect any worrying trends or abnormal readings;
- living environment, to ensure thermal comfort in extreme heat or cold by advance information to homes and controlling their systems;
- home safety and security, to ensure fire and flood prevention together with controlled access; and
- diet and nutrition, to ensure regular eating of healthy meals.

Mobility covers:

- personal mobility, to enable people to move with safety with suitable aids;
- public transportation, by using technology to plan journeys and reduce waiting time; and
- the older driver, by greater use of sensors to assist driving safely and by custom designed vehicles for older people

Community covers:

- networking, to reduce isolation and ensure participation in society;
- links to distributed families, by using simple communication devices;
- engagement in virtual communities, to provide social interaction;
- interaction with local community, by simple devices to ensure safety.

The theme of home and surroundings has also been taken up in the report of the Royal Academy of Engineering (RAE 2007) which stressed mobility, safety and independence in the home and the community as priority areas.

Mobility covers:

- driving – the need to understand better the needs of older drivers;
- public transport – improved accessibility and safer design, and improved information services to reduce waiting times;
- assistive technology for personal mobility – improved design and performance of traditional devices such as frames and wheelchairs; and
- joint replacement – improved performance of artificial joints to reduce revision surgery.

Safety and independence cover:

- smart homes – automatic alarms, central locking, intelligent appliances;
- neuroprostheses – improved implants for hearing, seeing and smell;
- incontinence – improved catheters, control valves;
- assistive and monitoring devices – sensing and recording critical health data, smart clothing, improved rehabilitation devices; and
- environmental design – ease of access, better communication systems, easier computer technology.

The last two approaches pick up the important issue of driving and safe transport as features of mobility outside the home. The traditional emphasis on risk is understandable given that motor vehicle crashes are a leading cause of injury and death in people 65 years and over. However, the importance of driving to a person's sense of independence and wellbeing needs to be taken into account, particularly in developed countries, since it is a key factor in the ability to participate in social and productive activities. Cessation of driving has been linked to a number of negative outcomes including depression and a decrease of activity in outside interests. Improving medical conditions and functional abilities of drivers, combined with modifications to vehicles and intelligent roads, provide opportunities for application of technologies (Marotolli 2009; Meyer 2009).

In Japan the emphasis appears to be on the dependent cohort, with the theme of safety and security in the home as reflected in automatic systems that control numerous functions or raise alarms when malfunctions occur. Advanced communication systems allow most tasks to be performed from the home. Strong application of robotics, intelligent mechatronics and exoskeletons (powered frameworks that assist movement) is seen as a route to assist patients with handicaps and thus cope with the anticipated shortfall in carers as the aged population increases (Dissanayake 2009).

The EU has launched an Action Plan for Ageing Well in an Information Society (see http://ec.europa.eu/information_society/activities/einclusion/policy/ageing/action_plan/index_en.htm) to tackle a range of issues such as raising awareness, overcoming technical and regulatory barriers, accelerating take-up of technology options, and boosting research and innovation. Under the Action Plan the European Commission has linked a number of activities in the AALIANCE project (the European Ambient Assisted Living Innovation Alliance) and the research theme of Information and Communications Technologies under the 7th European Framework Programme. Between 2009 and 2013, the EU (with support from Member States and the private sector) will invest more than €1 billion in research and innovation for ageing well; some €600 million in the Ambient Assisted Living Joint Programme, an expected €400 million in the EU 7th Framework Programme and more than €60 million on the EU ICT Policy Support Programme. There are also major programs in all the Western and Northern European countries but no overall figure is available.

A Roadmap for the AALIANCE project was produced in August 2008 to guide expenditure of funding (see www.aaliance.eu). It covers three areas in the field of ambient assisted living (AAL): AAL4persons (AAL@home, AAL@mobile), AAL in the community and AAL@work, and discusses technologies and barriers for their deployment in the three areas. The first area covers: AAL for health, rehabilitation and care; personal and home safety and security; personal activity management; biorobotic systems and AAL; and person-centred services. The second covers: social inclusion; entertainment and leisure; mobility. The third area covers: needs of older workers, support for working; working conditions; and safety and health regulations. A wide range of projects involving the technologies already noted above are in progress.

4.2 ELDERLY-FRIENDLY HOUSING

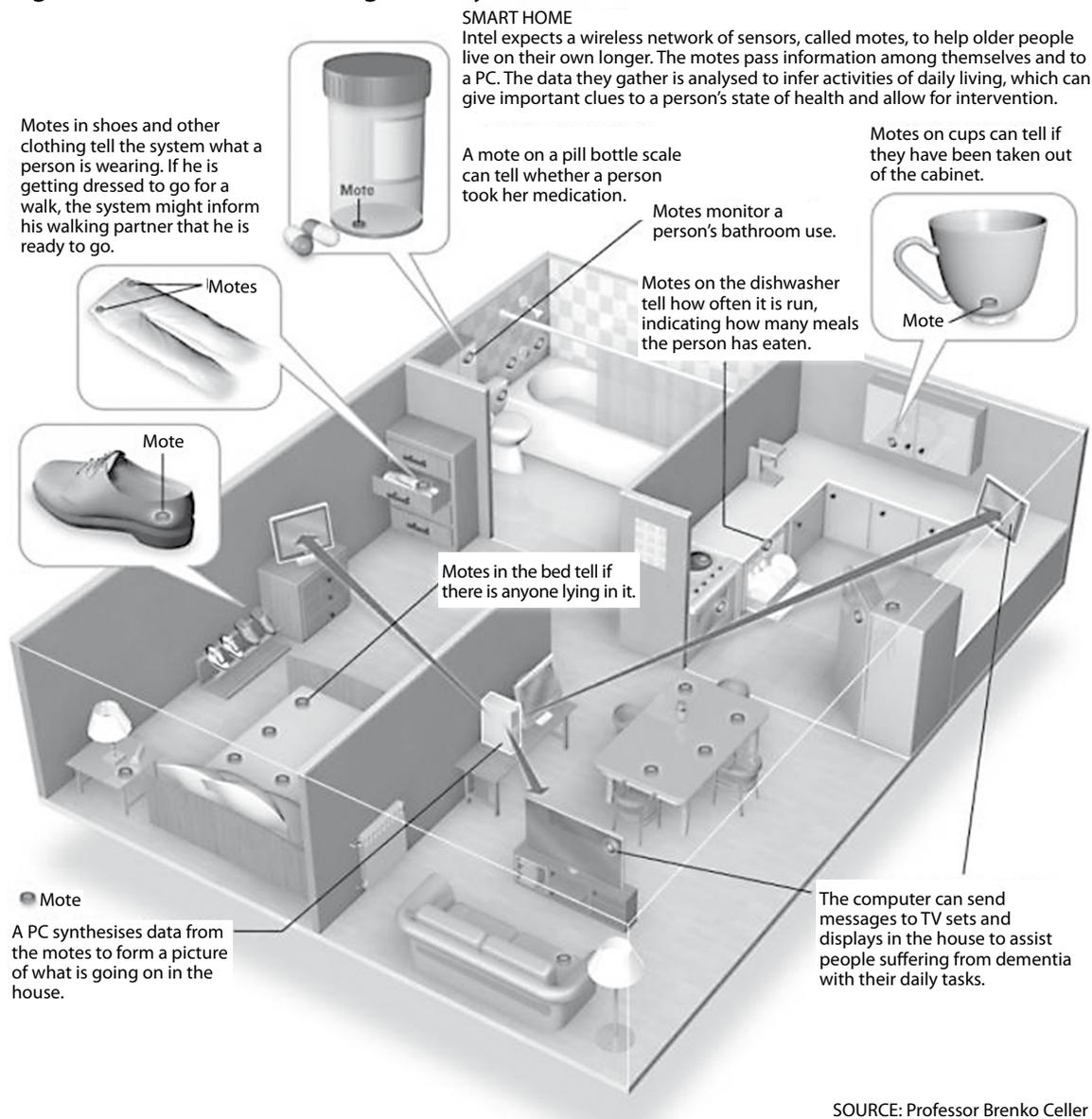
A number of the approaches in Section 3.1 contain the concept of elderly-friendly housing to allow ageing-in-place. Such houses can be created either by retrofitting of existing houses or by construction of custom-built smart homes. The benefits of such housing can be summarised as:

- empowerment of users and informal carers;
- provision of independence;
- improvement of quality of life;
- monitoring of health conditions;
- monitoring of daily living activities;
- assistance with crisis intervention; and
- reduced costs of independence.

Custom-built smart homes use converging technologies, principally information technology and increasingly nanotechnology, in the home to address intelligent health services, home automation, security and safety, communication and entertainment. An example of a smart home using an array of wireless sensors is shown in Figure 5.

Many of the technologies that are part of an overall smart home are already widely available, for example lighting and climate control, home computing, multimedia entertainment, gaming, etc. The connected home market is growing rapidly in North America, Europe and Australia and has potential in Japan. In

Figure 5 A smart home using an array of wireless sensors



considering smart homes for the elderly there is a need to build in systems for movement control, home diagnostic equipment, medication monitoring, fall prevention, simple communication devices for linking to family and support networks, as well as aids and monitoring for disabled people in the kitchen and bathroom (Chan et al. 2009). However there is confusion over standards and connectivity as different industry sectors approach the smart home market from different viewpoints. There is clearly a need for international protocols to facilitate the construction of smart homes (Franchimon and Brink 2009). In recent years there have been demonstrations of elderly-friendly houses in a number of developed countries, notably in Europe. Several of these are listed in Table 6 (see page 22).

The EU is funding a major project called SOPRANO (Service-Oriented Programmable smARt eNvironments for Older Europeans) under the 6th Framework Programme (see www.soprano-ip.org). This involves a number of countries and industry groups, aimed at development and proving of systems for standalone assistive technologies, smart home technologies and telecare services, particularly for frail and disabled older people. It started in 2007 and systems are ready for demonstration in houses in Eindhoven, Munich and San Sebastian. It is planned to install complete systems in 300 houses in the UK, Netherlands and Spain.

Table 6 Demonstrations of elderly-friendly homes overseas.

Country	Location	Details
Scotland	West Lothian	West Lothian Council from 2002:72 retrofit houses and 140 new constructions
	Dundee	Various retrofits
England	Gloucester	Smart home for dementia patients
	Northampton	Retro fit Safe at Home
Italy	Milan	Fondation Don Carlo Gnocchi: smart home for people with disabilities
Netherlands	Rotterdam	Humanitas Foundation from 1995:15 complexes, total 1700 Apartments for Life
Korea	Yonsei	100 homes built with wireless networking of appliances,telecare, sensors etc: 30 000 planned
Italy	Florence	Montedomini Health Care: 4 complexes,2000 homes with telecare

The lack of studies related to user needs is a major barrier to the expansion of elderly-friendly smart homes. Most of the studies have been pilot or short-term projects and the industry tends to be dominated by suppliers providing a technology-push rather than a demand-pull approach, often leading to user disappointment (Chan et al. 2009). The development of healthcare technology in the home appears to be limited in many cases by the inability of clinics and hospitals to exchange data and to interpret data obtained by user-centred systems in the home. The establishment of a national electronic health records scheme is a critical factor in expansion of elderly-friendly homes.

The most complete study of social and economic issues associated with elderly-friendly homes appears to be that carried out by the University of Stirling at West Lothian over a three-year period (Bowes and McColgan 2006). The report is a very rich source of insights into reactions from both formal carers and residents, allowing a radical re-thinking and re-designing of care and support services across a whole local authority.

The concept was to install a basic package of technology to all households with people aged 60 and over, whether the elderly residents continued to live in their own homes or in new Housing for Care developments. This package consisted of:

- a home alert console, which links sensors to a central call centre when they are triggered;
- two passive infra-red detectors to monitor activity and potential intruders;
- two flood detectors, activated by leaking pipes, overflowing baths etc;
- one extreme heat sensor, sensitive to both high and low temperatures; and
- one smoke detector.

In many cases the basic package was augmented by additional devices such as passive alarms such as fall detectors, video door entry systems, bed occupancy monitors etc.

The key lessons from the West Lothian experience were:

- smart technology was effective as a model of care promoting independence, choice and capacity-building and in supporting older people and carers.
- for staff, smart technology was a catalyst to a cultural change regarding service delivery.
- provision of smart technology packages to all households ensured that wider support was offered and that the stigma of using services was reduced.
- costs could be controlled, ensuring effective use of limited budgets alongside improvements in services.

5 Technological Opportunity Areas in Aged Care for Australia

5.1 IDENTIFICATION OF OPPORTUNITIES FOR GERONTECHNOLOGY IN AUSTRALIA

The discussions conducted in association with this project, at the ATSE workshops and with researchers and practitioners, have highlighted the wide diversity of activities in Australia covering technologies for the ageing population. These are being carried out in a wide variety of universities, research centres and industry. The research centres on health and ageing are mainly concerned with medical and social science aspects of ageing but these are often interlinked with technologies such as telehealth, service delivery, falls, control of wandering, home design etc. The scope of the centres can be seen from their listings (see www.era.edu.au/University-based+research+centres_in+ageing for many university centres and www.aag.asn.au/links.php for an overlapping list covering centres linked for collaboration through the Australian Association of Gerontology and the International Association of Gerontology and Geriatrics). There are many other centres and associations concerned with the research and application of technology for the well-being of the aged population outside these listings and there is no focus for all these activities, particularly when the approach of converging technologies is considered. The wide scope of such activities meant that only a limited number of Australia and Europe centres and researchers could be consulted in the scope of this study. There is a clear need for the creation of Centres of Excellence in Gerontechnology in Australia and for national coordination of activities in this area to ensure optimum use of resources of people and funding.

Based on the survey of the literature noted in Chapter 3 and the workshop discussions with many researchers and practitioners in Australia and Europe, an assessment has been made of the opportunity areas for large scale application of technologies for the ageing in Australia. These are summarised in Table 7 (page 24). Given that technologies typically take five to 10 years for commercial realisation (and often longer in the case of those applied to human health), the timeframe has been set for 15 to 20 years ahead. Clearly there are many possible technologies which could emerge in this timeframe.

Table 7 suggests how such widespread application might occur over the short, medium and long terms. In the short to medium timeframes, many of the technologies are already available and large-scale application will come through manufacturers and service providers engaging with the end-user population to understand how existing capability can be adapted to their needs, coupled with national policies on supply and funding. In the medium to longer term, others are in research and development or are being modified for application in Australia.

Selected technologies from the three areas, of particular concern to ageing-in-place in Australia, will now be discussed in more detail. These are

- security and safety: elderly-friendly homes, prevention of falls, communication and social interaction;
- diagnosis and treatment: telehealth, coping with degenerative diseases, nanomedicine; and
- assistive technologies: biorobotics, brain/machine interaction, mobility systems.

Table 7 Possible technology areas with large-scale impacts on elderly Australians in the next 15 to 20 years

Area	2008–13	2013–18	2018–23
Security and safety	<ul style="list-style-type: none"> – Tracking systems – Improved house design – Smart homes – Improved networking/communication – Safer transport vehicles 	<ul style="list-style-type: none"> – Implants for monitoring vital symptoms – Smarter homes – Falls alleviation – Smart clothing sensors 	<ul style="list-style-type: none"> – Personal sensory devices to provide data about social and physical environments – Sensors to detect composition of drugs, foods and biohazards – Sociable technology to enhance relationships with one another and with machines
Diagnosis and treatment	<ul style="list-style-type: none"> – Telemedicine for remote health monitoring – Devices for medication compliance – Wider use of biosensors for diagnosis 	<ul style="list-style-type: none"> – Rehabilitation robotics – Tele-rehabilitation, low cost haptic systems – Nanodelivery systems for medication – Biometric devices for identification 	<ul style="list-style-type: none"> – Diagnosis and control of neurodegenerative diseases
Assistive technologies	<ul style="list-style-type: none"> – Audio GPS for visually impaired – Aids for driving – Ultralightweight wheel chairs – Improved prostheses – Handling devices 	<ul style="list-style-type: none"> – Brain/neuro computer interaction – Improved vision and hearing devices – Exoskeletons for lifting objects – Enhanced mobility systems 	<ul style="list-style-type: none"> – Service robotics – Artificial molecular muscles

5.2 SECURITY AND SAFETY

Elderly-friendly homes

The concept of elderly-friendly homes is being actively pursued in a number of developments throughout Australia (QSHI 2006, CDC 2008, ACIL Tasman 2009, The Benevolent Society 2009). Details of some of these are given in Table 8. A key aspect of these is the incorporation of security and safety features, mostly based on imported equipment. The premise is that aged persons, disabled persons and chronically ill persons need greater assistance with heightened safety levels, while aged people living alone in particular seek greater security. Other aspects are health monitoring and communication as discussed later. A number of developments are based on retrofitting systems to existing homes while others are based on new custom-built smart homes (CDC 2008). In addition there are estimated to be some 100,000 homes fitted with wireless technologies for automated emergency response services connected to call centres (Croll 2009).

The approach of The Benevolent Society is particularly interesting (The Benevolent Society 2009). It is based on the experience of the Humanitas Foundation in Rotterdam which has changed its model of housing from aged care institutions to ‘Apartments for Life’ that give older people the opportunity to stay in their own homes until the end of life. Their complexes are designed to have older people, who require care, living in a socially interactive community with others who are healthy; the focus is thereby shifted from medical problems to healthy and happy living. By eliminating the negative age stereotype it is possible to produce a significant increase in life expectancy.

Table 8 Developments in elderly-friendly homes in Australia

State	Location	Details
Queensland	Brisbane, Kenmore	Blue Care Retirement Village – retrofit house 2007-08, sensors and assistive technologies
	Brisbane, Newmarket	Life Tec-New demonstration house, opened 2009, to be followed by large project of “101 Smart Homes” linked to overseas projects
New South Wales	Sydney, Marsfield	Baptist Community Services – retrofit house 2008, renovations, sensors, Tele Care
	Sydney, Bondi	The Benevolent Society – development application lodged 2008, amended 2009, 133 apartments, 7 townhouses
Western Australia	Perth, Bentley Park	SwanCare Group – approx. 800 dwellings ranging from free-standing villas to apartments

There would need to be modifications to the Building Code of Australia to cover conversion of current homes, and the construction of future homes, that provide access for mobility devices, ease of access to facilities such as bathrooms, kitchens etc, and installation of cabled and wireless systems. The principles of 'housing for life' are well documented and can be followed for as little as two to six per cent of the cost of construction (MBA 2009). The development of a policy on ageing-in-place is untenable without widespread accessible design (HMIC 2008). Since elderly people often remain in large family homes and become isolated, there is a need for a new approach to convert these homes and open up opportunities for younger families. When designing new solutions, manufacturers must recognise that the average user will probably not live in a purpose-designed smart home and may not have the means to alter their home to allow effective integration of assistive technology solutions.

Elderly-friendly homes incorporate technologies for security and safety. Security technologies cover a wide range including central locking, controlled access via smart cards or biometrics such as fingerprint scanning, remote surveillance via a central control, and automatic lighting systems. These are available commercially in Australia (CDC 2008). A number of technologies are available to enhance safety at home, such as smoke detectors, flood detection and automatic preset timed switching for appliances. Motion sensors can be installed to follow movements and to alert central monitors to unusual periods of inactivity. Residents can wear a personal emergency button on their wrists, or a pendant that can be activated to prompt an immediate response.

There is a clear need for larger developments of elderly-friendly housing in Australia and for detailed social science studies of the reactions of Australians, both carers and residents, in these environments. Such an approach was emphasised in the PMSEIC report (PMSEIC 2003), which recommended the development of a national strategy to "build a more age-friendly environment, supporting innovation in planning, design and technology to assist older Australians to maintain their independence at home with good quality of life". The strategy should include "improvements in land-use planning, transport investment, building regulations (in-fill, building of granny flats), design of public spaces (to allow safe walking) and community crime prevention".

Prevention of falls

A major opportunity for technology inputs to safety exists in the prevention of falls among older people, particularly at home. Throughout the developed world, falls are the major cause of accidental injury among people aged 65 and older (Victorian Government 2007). A widely acknowledged estimate is that one in three elderly people living in their own homes will fall at least once per annum. Many of these falls lead to hospitalisation. Hospitalisation rates in Australia show that fall-related injuries increase exponentially with age, with about a nine-fold increase in the rate in both males and females as they age from 65 to 85+ years. Falls are the leading cause of injury-related deaths among people 65 years and older. Clearly, with the future statistics in Table 2 there is a need to focus attention on preventing falls by the elderly in Australia. This also has economic implications in reducing hospitalisation costs (Tiedemann et al. 2008).

Research and development are actively underway in Australia in a number of areas:

- improved control of medication;
- early warning of balance and vision problems by monitoring with accelerometers (UNSW and TeleMedCare Pty Ltd);
- training in balance exercises (National Ageing Research Institute and Prince of Wales Hospital);
- better environmental design to reduce potential trip hazards; and
- introduction of assistive devices, for example hip protectors.

Widespread application of these techniques should lead to a decrease in falls.

Communication and social interaction

Mobile phones are now ubiquitous throughout Australian society. A recent survey by the National Seniors Association has found that 96 per cent of Australians aged 50 and over, and 90 per cent of those aged 70, own a mobile phone. This represents a major step in providing safety and security, both inside and outside the home. However, inadequate design and lack of training mean that seniors are missing out on many features like Internet and email, both from mobile phones and from home computers.

Only one in five Australians over 65 currently uses the Internet. This is being remedied through the Australian Senior Computer Clubs Association (ASSCA), which is the national peak body covering more than 120 member clubs in all States of Australia (see www.assca.org.au). ASSCA is a volunteer body that provides information, training, forums, seminars and workshops relevant to assisting older and disabled Australians to access computer technology. Such training enables them to communicate with family members and the wider world, to expand their knowledge and to use on-line financial services and e-commerce, thus generally enhancing their quality of life.

The implementation of the proposed national broadband network will further enable the elderly, particularly outside major cities, to have better access to internet services through the Broadband for Seniors Initiative (see www.fahcsia.au/sa/progserv/broadband). The Department of Families, Housing, Community Services and Indigenous Affairs (DFAHSIA) has contracted NEC and a consortium of the Adult Learning Australia, ASSCA, and The University of the Third Age Online to deliver this initiative. Up to 2000 kiosks are being set up through local community organisations and clubs used by seniors. The kiosks will provide computers, internet connections and training.

For elderly people with mild dementia or physical disabilities, communication systems using touch screens with designated links have been developed in various countries and these are being installed in elderly-friendly homes. Such systems provide a degree of security and safety in cases when unusual periods of inactivity are detected by family or carers.

An interesting project with considerable potential is the Memory, Appointment and Navigation Assistant (MANA) being developed through the ARC Special Research Initiative on Thinking Systems (see www.arc.gov.au). This is designed to assist elderly people, who have a progressive long-term decline in cognitive behaviour or with Alzheimer's or early onset dementia, to live at home independently. MANA is a virtual animated agent (with head and shoulders) that can remind people about appointments and taking medication and can provide memory training to assist rehabilitation and improve social interaction.

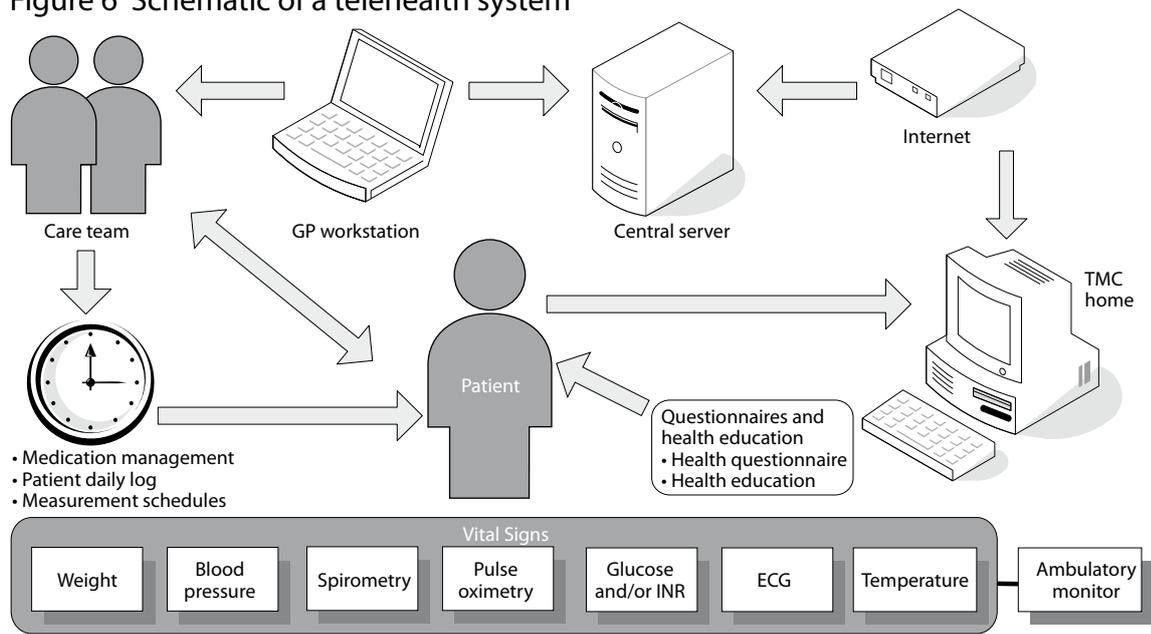
5.3 DIAGNOSIS AND TREATMENT

Telehealth

Australia has a long tradition of strength in the medical field. A major thrust has been the application of information technology to health issues, with ultrafast computing seen as ubiquitous in all areas and disciplines. A significant area is telehealth, which is the use of electronic information and telecommunications technologies to support remote clinical health care and the management and delivery of healthcare services from public and private health institutions. The aim is to facilitate support at a distance by a multidisciplinary team, including family members and friends.

Telehealth is of particular importance for ageing-in-place and the spread of elderly-friendly homes throughout the community. In the home, monitoring of vital signs can be carried out with simple

Figure 6 Schematic of a telehealth system



SOURCE: Professor Nigel Lovell, TeleMedCare Pty Ltd

wired and wireless instruments connected via telephone to web-based services and databases. More complex systems promote self-management by engaging with the user and providing a range of services such as health education, daily logs, medication reminders and the provision of alerts and alarms. There is a great deal of activity in this area in the US and Europe (IEEE 2009). As an example, various studies have estimated that a third to a half of prescription drugs are not taken as prescribed, or not at all, leading to needless hospitalisations costing \$100 billion per year in the US alone. As a result, new drug-delivery systems based on “smart pills” linked though wireless to monitoring centres are under development (see www.economist.com/business-finance/displaystory.cfm?story_id=15276730).

A telehealth system developed in Australia by TeleMedCare Pty Ltd (www.telemedcare.com.au) is shown in Figure 6. Hospital grade instruments, designed for simplicity and ease of use, are set up in the home. These include blood pressure monitoring, pulse oximetry, spirometry and electrocardiograms, as well as other simpler devices for measuring weight, body temperature and blood glucose. Data collected from these devices, together with a record of medications used and health status questionnaires, provide a detailed record for analysis by medical staff at call centres to enable timely intervention if required and for family to be involved in decision making. Further, such data are an essential input to self-management. Studies have shown that nearly 90 per cent of the care that a person needs to manage a chronic disease must come from the patient (Lovell 2010).

Self-management interventions such as self-monitoring, patient education and feedback, and decision making, lead not only to improvements in health outcomes, but also to increased patient satisfaction and reductions in hospital bed days and carer visits. Numerous studies show that telehealth monitoring services can have a significant impact on use of services (Celler 2009). Thus, visits to community doctors can be decreased by 40 per cent, outpatient visits can be reduced by 17 per cent and hospital admissions can be halved. Such changes can be achieved by the deployment of telehealth services throughout the primary care sector, including the home, in residential care, in GP practices and in community healthcare centres in rural and remote communities.

A simple application of wireless systems in health care is being studied at the Australian e-Health Centre in Brisbane (a joint venture of CSIRO and the Queensland Government – see www.aehrc.com). Against

a background of health lifestyle programs, patients undergoing cardiac rehabilitation use mobile phones to measure data and make on-line entries against set goals. These are then discussed at weekly conferences. The aim is to ensure that patients complete the standard six week outpatient rehabilitation program (currently less than 20 per cent complete the program after leaving hospital). This would be particularly helpful for the aged population living at home.

A significant issue in this area is the lack of standards. Without adequate standards, the Government will not achieve the economies of scale necessary for the widespread implementation of telehealth monitoring. In the medico-ICT area formats for both data and communications are needed, while in the medical records area costs can be significantly reduced by ensuring interoperability of record systems. With appropriate standards, it should be possible to develop a funding model for delivery of telehealth services. A recommendation from a UK report is particularly relevant: "It is important that policies ensure that all older people (including the frail old) are provided with appropriate technological support systems that are linked to electronic networks and that these policies are high on the agenda of policymakers and regulators, as they seek to ensure the widest possible access to the UK's emerging ICT infrastructure." (Ageing Population Panel 2000).

There is a clear need for large telehealth trials in Australia where systems can be installed in groups of elderly-friendly homes in rural as well as urban environments, to provide experience and data for evaluation, leading to the development of a national policy for telehealth.

Coping with Degenerative Diseases

An important consequence of demographic ageing in Australia will be the rapid increase in the number of people who have dementia. These are projected to increase from about 230,000 in 2008 to 465,000 in 2030 and to about 620,000 in 2040 (Access Economics 2005). The disease is rare in people under the age of 65 years but numbers increase markedly with age. Thus almost 40 per cent of those with dementia are aged 85 years and over. It is estimated that over 1000 people per week are diagnosed with dementia. Australia has a strong research effort on understanding the degeneration of the brain in older people and on the development of drugs to control dementia. There is great scope for delaying the onset of dementia, with associated substantial public health resource savings (Access Economics 2004b).

In 2008, about 60 per cent of people with dementia were living in the community and these were cared for by family carers and formal staff. Associated with the increase in the number of people with dementia will be a rapid rise in demand for care services and for the workforce to meet care needs. Recent modelling shows that by 2029 there will be an overall shortage of about 153,000 carers, comprising 94,000 family carers and 59,000 paid staff (Access Economics 2009). This means that in the future there needs to be an increasing proportion of elderly-friendly houses specially adapted to keep dementia patients safe and secure within the community rather than within institutions. In this respect Australia has much to learn from Europe, although there are wide variations in approaches between countries (van Hoof et al. 2009).

There is considerable activity in Australia directed towards understanding Alzheimer's disease and providing assistive technologies. Thus, the Australian Imaging Biomarkers and Lifestyle study (<http://www.aibl.csiro.au>) aims to improve understanding of the causes of Alzheimer's disease, examine lifestyle and diet factors which may influence its onset, and help develop methods for early diagnosis and preventative strategies. It involves CSIRO through its Preventative Health National Research Flagship, working with the University of Melbourne (Austin Health PET Centre), Edith Cowan University and the Mental Health Research Institute of Victoria. The study was launched in 2006 at the National Neurosciences Facility in Melbourne (see <http://www.neurosciencesaustralia.com.au/>).

The identification of wandering patterns indoors of patients with dementia in aged care facilities is being studied at the Australian e-Health Research Centre in Brisbane using RF sensors and accelerometers. Radio frequency identification has been trialled in some Australian housing developments, for example by the SwanCare Group in Perth, to monitor a resident's location. This is particularly applicable to high-care residents and those with dementia.

Other consequences of ageing are hearing and vision loss. One in six Australians is affected by hearing loss (Access Economics 2006). The prevalence of hearing loss is associated with age, rising from less than one per cent for people aged less than 15 years to 75 per cent for people aged over 70 years. With an ageing population, hearing loss is projected to increase to one in four Australians by 2050. Adverse health effects have been associated with hearing loss. While interventions such as hearing aids and cochlear implants enhance the ability to communicate, the majority of people with hearing loss (85 per cent) do not have such devices. Communication devices of various types for use at home are available but are limited in application (Access Economics 2006). Advanced communication systems being developed for smart homes will assist deaf elderly people.

Australia has an excellent record of research and application related to hearing, dating back to the mid 1940s. An outstanding example is Cochlear Pty Ltd, which has held 70 per cent of world market share for cochlear implants for the past 25 years. Its expertise was built on cochlear implant research at the University of Melbourne and the implantable electronics skills of the Nucleus group in Sydney. Currently, major concentrations of research exist in Melbourne where a new Audiology, Hearing and Speech Sciences Centre at the University of Melbourne was launched in May 2009, and in Sydney where Cochlear and Australian Hearing are moving to co-locate with the research group at Macquarie University. All these groups, together with Siemens Australia, are core members of the HEARing Cooperative Research Centre (see www.hearingcrc.org). Given this base, there is a strong capability, linked to appropriate policy actions, for ensuring that greater numbers of elderly people have access to both personal hearing aids and home communication devices.

Visual impairment is a huge and vastly under-treated problem in Australia (Access Economics 2004a). Over 480,000 Australians are visually impaired in both eyes and over 50,000 of these are blind. Because these conditions are age-related, visual impairment is projected to increase from 5.5 per cent of the over-40 population in 2004 to 6.5 per cent in 2024. The percentages of people with conditions such as cataracts, glaucoma and macular degeneration increases rapidly with increased age. In effect, everyone will eventually develop cataracts if they live long enough and half will have cataract surgery.

Visual impairment leads to other medical problems. Thus, people with high visual impairment have twice the risk of falls, four to eight times the risk of hip fractures and three times the risk of depression. Again, as with dementia, day-to-day care and support for people with vision impairment is often provided by family and friends as well as formal staff; increasing numbers will need additional carers.

There is a wide variety of aids, special equipment and home modifications that can assist the vision of the elderly in ageing-at-home, and these are used extensively (Access Economics 2004). There has also been global research activity directed to the development of a bionic eye. While this would be applicable to the population as a whole, the increasing number of elderly people in particular stands to benefit. A US company, Second Sight Medical Products Inc, has a system in clinical trials. It uses a camera and video processor mounted on sunglasses to send captured images wirelessly to a tiny receiver on the outside of the eye. In turn the receiver passes on the data to an array of electrodes that sit on the retina. When these electrodes are stimulated they send messages along the optic nerve to the brain which perceives patterns of light and dark. The hope is that these can be interpreted into images by the wearer.

Based on the success of Australian cochlear implant technology and the expertise developed locally in vision research, the Australian Government in December 2009 allocated \$50 million to two research teams for the development of a bionic eye in Australia (see <http://minister.innovation.gov.au/Carr/Pages/50MILLIONBIONICEYERESearchPROJECTSANNOUNCED.aspx>). One team, from the Universities of Melbourne, Western Sydney, New South Wales and ANU, will receive \$42 million to develop an implant device in the retina to assist blind patients suffering from degenerative retinal conditions. The other team, from Monash University and the Alfred Hospital, will receive \$8 million for an implant device in the brain's visual cortex, to treat progressive blindness. For more information, visit www.arc.gov.au/ncgp/sri/bionic_eye.htm.

Nanomedicine

Nanotechnology is defined as engineering at the molecular (i.e. groups of atoms) level. It is the collective name for a range of technologies, techniques and processes that involve the manipulation of atoms at the smallest scale, from one to 100 nm (PMSEIC 2005). Convergence of nanotechnology, biotechnology and information technology has led to the development of new areas such as nanomedicine, biocompatible materials, bioinformatics and nanobiotechnology and, from these, new approaches to health care (The Economist 2009).

Activities in the nanomedicine area can be classed as predictive, pre-emptive, personalised and regenerative (Schmidt 2007, European Commission 2005). In the predictive category, nanotechnology has the potential to help clinicians predict the major diseases that an individual is likely to develop, based on cheap and routine analysis of the 200 or so important biomarkers in blood using 'lab-on-a-chip' technology (see for example <http://en.wikipedia.org/wiki/Lab-on-a-chip>). In the pre-emptive category, early detection of diseases could lead to treatment to pre-empt the major onset of disease and to manage it effectively on a long-term timeframe. Examples of attractive candidates for pre-emptive treatment are diabetes, cardiovascular disease, hypertension and some cancers. In the personalised category, the compilation of a wide range of information about an individual offers the promise of a more effective medical strategy based on a number of drugs tailored to particular needs.

An excellent example covering these three activity areas is the development of rapid and inexpensive DNA sequencing technology and its application to diagnosis and treatment of diseases (APEC CTF 2003, The Economist 2009, Pond 2010). Since the initial sequencing of the human genome in 2001, there has been remarkable progress in lowering costs and enhancing the accuracy, reproducibility and throughput of analyses. Costs are now down to less than US\$10,000, with a processing time of seven days (Winslow 2010). Many companies are now setting a target of under US\$1,000 to sequence an individual's genome by 2014.

Full genome sequencing offers the prospect of detection of disease-related genetic variations for an individual. As an example, glaucoma is the second most common cause of visual impairment and blindness, with about 60 million sufferers worldwide (WHO 2004). One type of glaucoma (exfoliation glaucoma) has a genetic origin (Thorleifsson et al. 2007) and has prevalence rates of 10 to 20 per cent amongst people aged over 60 years. Lack of symptoms in the early stages of the disease severely hampers effective diagnosis and treatment, so an appropriate genetic test would be invaluable in managing the disease.

Notwithstanding the rapidly decreasing costs of full genome sequencing, the ability to identify accurately, analyse and extract information from minor variations in a typical sequence of six billion base pairs found in the human genome presents formidable challenges for bioinformatics. Practical and widespread uptake of DNA technologies will require the development of expert systems and the interpretation of data in a form usable to health practitioners and patients (Sintchenko 2010).

This offers an opportunity for a more creative approach to healthcare knowledge and information management (Pagan et al. 2008).

Finally, in regenerative medicine, where most attention has been focused on the potential of stem cells and cell-based therapies, nanotechnology could lead to radically new treatments for spinal cord injury, macular degeneration and diabetes. Particular emphasis has been placed on biomaterials, which are materials with novel properties that make them compatible with living tissue (European Commission 2007). Thus, there is research on nanomaterial scaffolds that can be infused with cells to form artificial tissues, such as bone or liver. It may be possible to repair damaged nerves by injecting them with nanomaterials that form bridge-like lattices. This area of research on the interface between cells and nanostructures is known as nanobionics (Moulton and Wallace 2008).

In recent years Australia has developed a strong research activity in nanotechnology to complement strengths in biotechnology and information technology. The convergence of these technologies has led to activities in medical bionics such as the cochlear implant and the bionic eye. There was a significant conference in the Sir Mark Oliphant International Frontiers of S&T Conference Series at Lorne in 2008 on “Medical Bionics – a new paradigm for human health” (see www.science.org.au/publications). This conference brought together Australian and overseas researchers to exchange experiences in a number of fields. The potential importance of the medical bionics industry has again been emphasised recently (Shepherd 2010). In 2010, the US market was estimated at more than \$1.8 billion. Further, there is a strong thrust to link nanotechnology and biotechnology into the field of nanobiotechnology, to produce biosensors and drug delivery systems. The recent biennial conferences on nanoscience and nanotechnology, ICONN 2006 in Brisbane and ICONN 2008 in Melbourne, included symposia covering many applications of nanobiotechnology.

5.4 ASSISTIVE TECHNOLOGIES

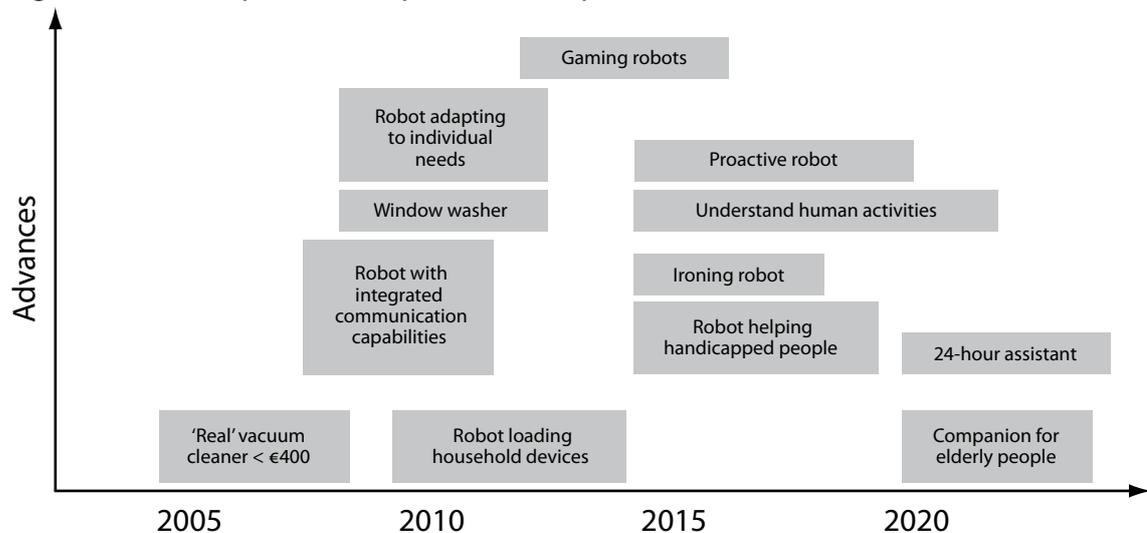
Biorobotics

Industrial robots are well established for routine tasks in industry, particularly in mass production plants, but only a few robot manufacturers have ventured into biorobot or service robot development. In contrast to industrial robots, service robots are designed for specific tasks generally taking place in an unstructured environment where there is still the possibility of direct human-robot interaction. Numerous components of biorobots can be adopted from industrial robot technology but there is need for significant extensions in functionality and increased performance for environmental perception, navigation, task planning and interaction and communication with humans.

While robots appear to have potential for assisting with routine tasks in the home, so far floor cleaning has been the main successful application for robots, especially in Korea. While many prototypes of service robots have been constructed, particularly in Korea and Japan, most have been unable to move into large-scale production. A major barrier is the lack of universally accepted standards to support development of inter-operating devices and systems. High cost and acceptability are other barriers. The concept of co-worker robots, designed to help humans in some way, is being actively pursued in many countries, with applications ranging from gardening and home cleaning to assisting a user with simple tasks in the home. Figure 7 (page 32) shows a roadmap produced by the European Robotics Research Network for possible developments in adaptive robot servants in smart homes over the next 15 years (EURON 2004).

An increasing number of pilot experiences, in which animaloids and other companion robots were investigated as potentially useful agents for the care of older people, has been published in recent years,

Figure 7 Roadmap for development of adaptive robot servants and smart homes



SOURCE: European Robotics Research Network

particularly by researchers in Japan and the USA (Broekens et al. 2009). Two different paradigms play important roles in this area:

- Ubiquitous Robotics, which concerns the investigation of robots as agents of an intelligent living environment, aimed at providing older people with a mix of physical and cognitive support in their everyday life; and
- Sociable Robotics, which relates to the non-verbal and emotional component of human-robot interaction.

An interesting area is how robotic creatures can be used with beneficial effects for patients suffering from dementia, not only as emotional activators but also as cognitive stimulators, by exploiting their interactivity and limited processing ability (AAL 2009).

Another area of biorobotics is their use for rehabilitation. Traditionally, physical therapy is provided in hospitals or rehabilitation centres for one-hour sessions, usually once or twice a day. The possibility of increasing the effectiveness of rehabilitation using robot-mediated therapies is being actively investigated around the world and the past decade has seen a remarkable rise in activity in this technology (Krebs et al. 2008). The physiotherapist must programme and control a robotic device able to replicate (and possibly improve on) traditional therapeutic strategies. Two types of devices have been developed. The first are operational machines, where users with moderate disabilities follow set patterns on fixed machines. The second are exoskeletons, which are wearable devices designed to assist joints on severely disabled users. The latter need external power sources and are complex and costly (AAL2009). There is growing interest in the potential for exoskeletons to allow people to lift heavy weights with less effort. A potential application is for nurses to lift obese patients without injuring their backs (<http://technology.newscientist.com/article/dn1072>). Given the increase in obesity in the community this could be a major problem in future aged care.

Currently there is little activity in this area in Australia. The ARC Centre of Excellence for Autonomous Systems at the University of Technology Sydney has developed expertise in intelligent robotic systems that are able to coexist and interact with humans (Dissanayake 2009). Attention has been directed to providing decision-making systems for walkers to improve gait stability and for wheelchairs to assist navigation. UTS has also started a project on exoskeletons to augment the user's upper limb, with applications to carers lifting patients and to the rehabilitation of aged people with disabilities

(Carmichael 2009). Given the potential applications noted in the roadmap of Figure 7, there is a need to build up Australian research on biorobotics.

Brain/machine interaction

Human machine interfaces covers any technology that allows humans to interact with technological devices. There are two kinds of interface that make use of the brain's neural impulses, brain/computer and brain/machine. The former refers to techniques that intercept and make use of neural impulses in the brain through brain imaging technologies, to control a device through basically non-invasive interfaces. The latter refers to invasive interfaces based mainly on retrievable cardiovascular approaches to measure neuron activities (Compano 2008).

As noted above, the convergence of technologies means that some of the applications of brain/machine technology overlap with those already discussed, for example the bionic ear and the bionic eye. An area of research with application to ageing is that of brain stimulation and regulation. In deep brain stimulation, an electrode is implanted into the subthalamic nucleus or basal ganglia of the brain to which electrical impulses are sent. Currently deep brain stimulation and similar techniques are mostly being explored for severe cases of disease or illness where alternative, less invasive techniques have failed. The methods have been used in very severe cases of epilepsy or depression and show promise in age-related diseases such as essential tremor, Parkinson's disease and Alzheimer's disease.

Human memory worsens with age. Researchers aiming to slow the natural decline have tended to use drugs. Non-drug based options have been limited by a lack of understanding of the memory process and how it declines with age. Although some essential insights are missing, it appears that the hippocampus plays a key role in the memory process. In Alzheimer's disease the hippocampus is one of the first brain regions to suffer damage, leading to memory problems and disorientation. A possible approach in the longer term is to replace some of the hippocampus functions with a silicon chip.

Another approach to slowing the decline of intellectual capabilities in old age is to maintain so-called 'brain plasticity', which refers to neural changes that occur in the organisation of the brain. One proposal is to use neurofeedback based on brainwave activity, as measured by electrodes on the scalp, in the form of a video display, sound or vibration. It is believed that, after some training, a user could be able to take conscious control of brainwave activity and thus contribute to maintaining cognitive abilities.

There is considerable activity in Australia in brain research, particularly in relation to ageing. The National Health and Medical Research Council (see www.nhmrc.gov.au) supports research on the brain and ageing at a number of universities around Australia. A clear understanding of the mechanisms involved in brain degeneration is vital to developing suitable technologies to alleviate problems arising from degeneration. The ARC Special Research Initiative on Thinking Systems, carried out in collaboration with NHMRC (see www.arc.gov.au), has one stream dedicated to 'Navigating Through Real and Conceptual Space' at the Queensland Brain Research Institute, which is using insights from neurocognitive systems to develop computational models, autonomous robots and intelligent software agents.

Mobility Systems

Mobility is a major issue for older people and is particularly important for social interaction. In Australia, the large proportion of the population in urban environments means that short to medium distances are involved in journeys. In rural areas, the relatively small population leads to travel over very long distances. Possible modes of transport in urban areas are walking, cycling, wheelchairs, motorised scooters, cars and public transport (Whelan et al. 2006).

Non-motorised modes of transport are becoming more popular and are beneficial to individuals and the community by increasing fitness, health and longevity. However, as people age or develop impairments, they are at greater risk of serious injury and death. In Australia, pedestrian fatalities make up about 15 per cent of all road fatalities. A significant proportion of these involve older adults, who are vulnerable because of frailty and poorer judgement of traffic density and speed. They often find difficulty in negotiating pedestrian environments. Geo-referencing and route guidance using satellite, wireless or mobile phone technology can help pedestrians and cyclists, by providing not only relevant and useful information but also reassurance in unfamiliar environments. This is very important for people with a sensory impairment (particularly a vision impairment) to find their way around buildings and large public spaces. Such technologies are referred to as 'way-finding' (CRC for Construction Innovation 2004).

These services are becoming more common. Widespread penetration of mobile phones and wireless devices could enable a majority of older people to use such technology and provide a market for further development (McCreadie 2005). These may well develop into personal wearable devices. The exciting prospect is the ability to interact within a wireless network deployed as part of a pervasive intelligent infrastructure set up to support travel and transport services, including pedestrian movements (AAL 2009). Wheelchairs can be fitted with wireless positioning systems. For frail and permanently disabled people, robotic agents are being developed at UTS to assist with daily actions via a decision-making mechanism that requires minimal indicative input from the user (Taha et al. 2008).

Personal mobility is a key factor in independent living of older people and mobility scooters are becoming increasingly popular as an alternative to driving a car. A recent estimate indicates that there are now over 100,000 in Australia. While they offer substantial mobility for many older adults who find walking difficult, there are increasing safety concerns (Lawes 2010). These vehicles are designed for short-distance trips in urban areas but much of the road infrastructure, for example crossing and signage, does not cater for widespread use of mobility scooters. Further, they often have to share the road with faster cars, with the potential for accidents with severe consequences due to the limited occupant protection on scooters. This is particularly true in rural areas where mobility scooters are sometimes used for reasonably long trips along major traffic routes. The projected increase in the aged population in urban areas in Australia poses a unique challenge for scooter manufacturers, designers and traffic management.

Most older drivers wish to continue driving as long as possible since it gives them a high degree of independence and is considered comfortable, faster, and safer than public transport (see special issue of *Gerontechnology*, June 2002 Vol.1, No.4 on 'Driving in Old Age: Use of Technology to Promote Independence'). However, older drivers often show decreasing motor skills, vision and hearing and slower reaction times. This decrease of capabilities means that older drivers have a higher accident rate than middle-aged drivers, though usually at lower speeds. However, they are generally frailer and, other things equal, suffer greater injuries than younger people.

Car manufacturers are conscious that older customers are an important market segment for higher-priced cars and are introducing additional safety measures beyond the normal passive and active (for example electronic stability programme) safety measures. Examples are: tyres with flat running capability, night-vision systems, blind-spot detection, head-up displays showing relevant driving information as a virtual image, speech input for operation of functions, and improved navigation aids. In future, intelligent infrastructure through sensors and wireless systems will provide inputs and take over some of the driving. This will reduce the problems that older drivers can have at complex interchanges and on multilane roads. As the aged population increases, it will increasingly be important to design roads that will accommodate the needs and capabilities of older drivers.

For public transport, the challenge is to provide intermodal systems that operate seamlessly and reduce stress on travellers. For older travellers, full information needs to be available about facilities, travel times and accessibility, through clearly visible displays and touch screens.

In Australia, many of the developments in vehicles will come from overseas through vehicles designed elsewhere. However, systems often need to be adapted to meet Australian standards, and studies of older Australian drivers can also provide useful inputs for design (Charlton et al. 2002). There are also opportunities in Australia for innovative use of materials and design in personal transport. An example is the development in Sydney of a multipurpose wheeled mobility device called the Freedom Wheelchair, which can be used as an everyday chair, a commode chair, a shower chair and a travelling chair (see www.azonano.com/News.asp?NewsID=5336). At 5.1 kg it is lightweight compared to a standard wheelchair, which can weigh up to 12 kg. The weight reduction is achieved by the use of Sandvik Nanoflex, a high strength nanotechnology-based thin wall stainless steel tube, and novel fabrication techniques.

SMART TECHNOLOGY FOR HEALTHY LONGEVITY

6 Social and Ethical Issues in the Application of Technologies for Elderly People

As noted above there is a wide range of possibilities for application of technology to assist elderly people to maintain physical independence, autonomy and quality of life. In the near future, elderly-friendly homes and other areas are expected to become integrated components of ambient intelligence networks, which will learn from individual users and their environments and react to changes. Thus, unobtrusive sensors and monitoring devices will be placed in homes and on people, and will be connected to clinics and hospitals at the other end, where information will be collected and analysed. If necessary, there will be a response via personal interaction with the resident or wearer. The integration and use of such technologies in home environments of the current generation of older persons is somewhat challenging for many, but as the next generation ages this cohort will be more familiar with, and thus potentially more accepting of, such innovations (van Hoof et al. 2007).

It is not difficult to see a number of benefits with the application of these technologies. There are at least five reasons for introducing such systems (Collste 2009). Firstly, the system has the potential for monitoring people suffering from chronic illnesses, who need long term attention but not necessarily continuous treatment. The benefits are both personal and economic, through delaying their transfer to assisted care. Secondly, in cases of emergencies such as falls, personal health monitoring will speed necessary relief actions. Thirdly, the ability to access specialists at a distance could be useful in areas where there is a shortage of medical staff or in rural and remote areas. Fourthly, personal health monitoring can function as an early warning system for a variety of medical conditions and in maintaining a healthy lifestyle. Finally, the system may be able to provide different kinds of social and technical support if healthcare resources are stretched. Technicians may acquire a new role and become direct players in facilitating care of dependent elderly people, leading to new models of care.

Thus, there are many good reasons to introduce such technologies into the home environment. However, one can envisage threats and vulnerabilities connected with these technologies. Specific issues are to do with privacy, autonomy, informed consent, identity and dignity.

Privacy

Privacy is an important concept in both law and ethics. The exact meaning of privacy can be disputed but in ethics it generally has two meanings, to be left alone or to control information about oneself (Collste 2009). With home monitoring there is always some form of intrusion into personal space, however inconspicuous it may seem. Thus, monitoring needs to be carried out with the consent of the person, who can turn off monitoring devices if so desired.

As for control of information, there is always the risk of leakage when sensitive information is transferred to clinics. The amount of information that can be gathered by continuous monitoring using a range of

ambient technologies is much greater than previously obtained by intermittent medical consultations. Hence it could be of potential value for commercial purposes or insurance companies. This is particularly the case with DNA data where, despite the benefits of predicting disease risk in the aged, genetic testing may also cause problems. Thus, if the results of genetic testing are included in a person's normal medical records, there is a possibility of discrimination by employers and insurance companies if there is evidence of genetic predisposition to cancer, mental illness and neurodegenerative diseases (Parker 2010). This raises legal issues since with many diseases both historical and environmental factors at a cellular level play a major role in disease development. The relationship between these factors and genetic predisposition is still poorly understood. Thus many healthy people may not develop conditions such as glaucoma, cardiovascular disease, stroke, Alzheimer's disease or diabetes, even though they may possess genes that increase their susceptibility to those conditions.

Although several countries have laws that help to protect people against discrimination, genetic testing is growing so rapidly that it is unclear whether existing legal frameworks are sufficiently robust to offer appropriate coverage. In Australia in 2003, a joint enquiry by the Australian Health Ethics Committee and the Australian Law Reform Commission led to an amendment of the Privacy Act regarding the disclosure of genetic information by health practitioners. The amendment required the development and issuing of guidelines to assist in making decisions about disclosure. These were released in December 2009. They permit doctors to disclose information to a genetic relative of a patient without consent in situations where such disclosure is necessary to lessen or prevent a serious threat to the life, health or safety of the patient's relative (see <http://www.privacy.gov.au/materials/types/guidelines/view/7015>).

Autonomy

A certain degree of autonomy is needed in order to live a fulfilled life and ambient intelligence systems do threaten autonomy. All networked packages and services collect and transmit some form of data ranging from simple logs of internet usage to more sensitive data on banking and very private or intimate data on health status. The question arises as to the extent that such data collection is privacy-sensitive and how much a person's autonomy could be threatened by the transfer of power to others. Thus, there is a need to ensure that systems designers take the protection of privacy into consideration at an early stage

Informed Consent

A particular problem relates to the informed consent of that group of elderly people with dementia (van Hoof et al. 2007). For example, radio frequency identification devices (RFID) in bracelets have been trialled for tracking elderly people with dementia, for whom wandering is a potentially lethal risk. The use of such tracking systems is justified on the basis that a slight loss of liberty is justified by the increase in safety. A logical development is the incorporation of such devices into 'smart fabrics' for clothing (Chan et al. 2009). RFID technology is already being used by textile manufacturers for inventory control but there is concern that its widespread use such as in the example cited could raise privacy issues (see www.boycottbenetton.com/news).

However the most difficult problem in ethical decision-making for dementia sufferers appears to be in assessing the degree of dementia and the associated wide range of behaviours. The question arises as to how to obtain informed consent for various technologies. There is a significant risk of 'technological paternalism', where the healthcare system acts to control people in their perceived best interests, perhaps without their consent.

Identity

There is an argument that when tracking systems are used, either attached or implanted, self-identity could be affected. This may not seem particularly important but self-image is important to well-being and needs to be considered as one of the ethical issues.

Dignity

Older adults attach particular importance to security in and around their home. However this can conflict with maintaining their dignity. Thus, some qualitative studies have found that, while some elderly people accept being monitored naked in the bathroom rather than take the risk of falling and lying unconscious and in need of care, others object to such surveillance and are prepared to take the risk. More studies are needed to understand the motivation of elderly people in balancing dignity and security.

The significant questions facing the use of ambient monitoring systems for the benefit of elderly people are:

- how to communicate the nature of the privacy risks that they face;
- how to control the options that they have; and
- how to exercise control over the capture and use of information from their environment.

Continuing research in Australia in these areas is essential for the future welfare of the aged population.

SMART TECHNOLOGY FOR HEALTHY LONGEVITY

7 Conclusions

The study has raised a number of important issues which need to be addressed by Australian governments, industries and researchers if smart technology is to play a significant role in dealing with the needs of future aged populations.

DEMOGRAPHIC CHANGES AND THE CHALLENGES OF AN EXPANDING AGED POPULATION

1 The future population of Australia is projected to reach 36 million by 2050. This increase will likely be concentrated in current urban conglomerations and will be associated with a major demographic transition to a much larger proportion of older people, with 7.8 million over 65, including 1.8 million over 85. This transition will require a new approach to housing, urban planning and transport to deal with the increased aged population.

2 While the larger number of old people could have a positive impact on society if their healthy years can be extended, they also have higher healthcare demands due to chronic illness, disability and degenerative diseases, leading to increased costs to the Australian and State Governments.

3 There is an urgent need for government to consider how technology in a variety of areas can be adapted and developed to reduce these costs and at the same time improve the quality of life for the aged. Ageing-in-place offers the potential for substantial savings in residential aged care and in overall health care for the aged, through the application of new technologies, particularly wireless communications.

4 The development and application of smart technologies for coping with ageing offers opportunities for Australian business and industry to open up new markets for services and products, both domestic and export. A radical change of mindset is needed to overcome the current stereotype of aged people as unable or unwilling to deal with new technology.

RESPONDING TO THE CHALLENGES THROUGH TECHNOLOGY

5 There is a continuum of ageing through informed, dependent and supported stages. At each stage technology can help maintain a healthy, secure and safe environment. A major contribution can arise from elderly-friendly housing that uses ICT solutions to address social communications, personal health monitoring, telehealth, shopping and cognitive training. While the required technology can be installed in existing homes, future dwellings will need to be specially designed to incorporate such systems. Modification to the Building Code of Australia will accordingly be required.

6 Many technological solutions already exist but are not being fully utilised. Reasons include: individual devices not compatible for linking to a common control system; poor design for ease of use and maintenance; lack of consultation with users about their needs; high cost; and lack of policy on financing. There is a need for: national and international protocols for connection of wireless devices; improved human-centred design; improved awareness in industry and business of the potential markets for technology for the aged population; and national policies for funding elderly-friendly homes.

7 The complexity of the challenges in applying technology to the needs of the aged calls for bringing together a wide range of technologies to focus on solutions. The concept of ‘converging technologies’ based on nanotechnologies, information and communication technology, biotechnology and cognitive science offers a new approach to issues of healthy longevity. In Europe this approach has been termed ‘gerontechnology’ – the convergence of medical aspects of ageing (gerontology) with technology to assist daily living. This is a well-established concept overseas, which needs to be promoted in Australia in education, research, industry and business. This approach fits closely with the objectives of the National Enabling Technologies Strategy.

WHAT IS HAPPENING OUTSIDE AUSTRALIA?

8 There is significant activity in the development of technologies for the aged population, particularly in Europe, the USA and Japan. Many papers and reports have been published, which identify a large number of promising technologies, essentially all focused around the topics of wellbeing, mobility, social interaction and security and safety.

9 While there are major national programmes, the EU has been active in developing a Europe-wide approach through its Action Plan for Ageing Well in an Information Society. This focuses on a number of issues such as raising awareness, overcoming technical and regulatory barriers, and boosting research and innovation. Between 2009 and 2013 the EU and member states, together with the private sector, will invest more than €1 billion in research and innovation for ageing well.

10 The engineering communities in Europe have been extremely active through their Learned Academies and professional associations in calling for increased support by their Governments for development and application of technologies to provide for their ageing populations. ATSE and the other Learned Academies in the National Forum and Engineers Australia have a major role to play in raising awareness of gerontechnology in Australia.

11 Europe has been particularly active in promoting the concept of elderly-friendly housing and there are now thousands of such homes. Special attention is being given to housing for dementia sufferers, against the rising tide of dementia among the elderly and the projected shortage of carers. This has also been identified as a major problem for Australia.

12 The application of smart technologies in Europe is leading to new models of care and this has implications for the training of health professionals and technicians and their delivery of care. There are so far few detailed studies by social scientists of the reaction of the ageing population to the new methods of healthcare delivery in elderly-friendly housing and of the impact on hospitals and community health care. There is a pressing need for large-scale developments of elderly-friendly housing in Australia linked to studies of aged people in these environments.

13 The limited studies available indicate that substantial savings are possible through the application of technologies in reducing admissions to hospitals and dependent care by early alerts to changing health patterns and by minimising risk of falls and other accidents in the home. However more detailed studies for Australia are needed.

TECHNOLOGICAL OPPORTUNITY AREAS FOR AUSTRALIA

14 Australia has a large number of people involved in various aspects of technology for ageing, from biomedical to assistive technologies, and in many of these areas the standard is comparable to overseas. For example, based on the worldwide success of the development and commercialisation of the bionic ear, a major project on bionic vision is underway. In telemedicine Australia is a world leader, particularly for remote communities, but commercialisation of local research has proved to be difficult. Research on management of chronic diseases at home and on prevention of falls is excellent.

15 The discussions at the ATSE workshops (see Appendix A) together with the visits and discussions with a wide spectrum of interested parties, have identified a number of technological opportunity areas for Australia, based on existing research expertise and on future needs identified in the literature and in discussions in Paris. These have been classified under the headings of security and safety, diagnosis and treatment, and assistive technologies. The timeframe for realisation is up to 15 to 20 years for the more intrusive technologies involving implants.

16 Selected technologies from each of these three areas have been discussed in detail, as follows:

- security and safety – elderly-friendly homes, prevention of falls, communication and social interaction;
- diagnosis and treatment – telehealth, coping with degenerative diseases, nanomedicine; and
- assistive technologies – biorobotics, brain/machine interaction, mobility systems.

All of these areas link together nanotechnology, biotechnology, ICT and cognitive science in various ways. In all of these technology areas there is potential for development by business and industry in line with the objectives of the National Enabling Technologies Strategy.

17 While there are many formal centres of activity on health and ageing in a number of universities around Australia, there are no centres for gerontechnology as exist in Europe and North America. There are uncoordinated activities on technology for ageing, particularly in Melbourne, Sydney and Brisbane, while there is an overall lack of coordination on a national basis. Where clusters of expertise exist, universities and research institutes should be encouraged to set up Centres of Excellence in Gerontechnology with joint ARC/NHMRC funding support. These need to include social scientists, physicians working in aged care, and designers. In particular they need to draw on structured inputs from aged people with a range of views on using technology in their daily lives. The creation of a Cooperative Research Centre on Smart Technology for Healthy Ageing would be a significant step to link research more closely to business and industry.

18 Unfortunately it is not possible to estimate the current expenditure on research on smart technologies for ageing in Australia since it is dispersed in a variety of funding schemes. As a rough guide, total health research expenditure in Australia in 2004-05 was \$2.8 billion with clinical research at \$1.42 billion, human pharmaceuticals \$548 million, public health \$536 million and health and support services \$250 million. While all these have links to gerontechnology, there is also major research under S&T programs such as nanotechnology, biotechnology, ICT and cognitive science, which are also relevant to gerontechnology. A compilation of activity and funding on technology for ageing in Australia is urgently needed.

SOCIAL AND ETHICAL ISSUES

19 There are important ethical, social and legal issues raised by application of technologies to improve the life of elderly people. With improved communications, while there are positives such as better connection to families and community with empowerment of people, there are negatives in terms of increased susceptibility to loss of privacy, fraud, lack of personal contact etc, particularly if mental impairment occurs. Unseen monitoring systems for the elderly that report to a central base to enable a response to perceived problems raise serious privacy issues. The sacrifice of privacy for safety and security is exacerbated in the case of dementia.

There is a need to address these issues at on a national basis in Australia. The National Academies Forum could be an ideal group to lead the debate.

8 Abbreviations and Acronymns

AAL	Ambient Assisted Living
AALIANCE	European Ambient Assisted Living Innovation Alliance
acatech	German Academy of Science and Engineering
AIHW	Australian Institute of Health and Welfare
ANU	Australian National University
APEC	Asia–Pacific Economic Cooperation
APEC CTF	APEC Centre for Technology Foresight
ARC	Australian Research Council
ASSCA	Australian Senior Computer Clubs Association
ATSE	Australian Academy of Technological Sciences and Engineering
CAPPE	Centre for Applied Philosophy and Public Ethics
CDC	Copper Development Centre (Australia)
CRC	Cooperative Research Centre
DFAHSIA	Department of Families, Housing, Community Services and Indigenous Affairs
DNA	Deoxyribonucleic acid
EU	European Union
EURON	European Robotics Research Network
FTSE	Fellow, Australian Academy of Technological Sciences and Engineering
GDP	Gross Domestic Product
GP	General Practitioner
ICONN	International Conference on Nanoscience and Nanotechnology
ICT	Information and communication technologies
LSIF	Life Sciences Innovation Forum
MANA	Memory, Appointment and Navigation Assistant
MBA	Master Builders Association (Australia)
MOBILATE	Enhancing outdoor mobility in later life
NAE	National Academy of Engineering
NATF	National Academy of Technologies of France
NHMRC	National Health and Medical Research Council

SMART TECHNOLOGY FOR HEALTHY LONGEVITY

NSTDA	National Science and Technology Development Agency (Thailand)
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
QSHI	Queensland Smart Home Initiative
RAE	Royal Academy of Engineering
RFID	Radio frequency identification device
SARS	Severe Acute Respiratory Syndrome
SOPRANO	Service-Oriented Programmable Smart Environments for Older Europeans
UNSW	University of New South Wales
UTS	University of Technology, Sydney
WHO	World Health Organization

9 References

AAAL, 2009, “Ambient Assisted Living Roadmap”, The European Ambient Assisted Living Innovation Alliance, VDI/VDE/IT, Berlin.

Acatech, 2009. The German Academy for Engineering Sciences (www.acatech.de) has been a participant in a Joint Academies study on “Aging in Germany” (www.altern-in-deutschland.ed/en/) which has a number of topics including Technology, Products and Services, and Body, Mind, Health and Brain.

ACIL Tasman, 2009, “The Apartments for Life Housing, Care and Support Concept for Older People”, Report prepared for The Benevolent Society.

Access Economics, 2004a, “Clear Insight-the Economic Impact and Cost of Vision Loss in Australia”, Report prepared for Eye Research Australia.

Access Economics, 2004b, “Delaying the Onset of Alzheimer’s Disease; Projections and Issues”, Report prepared for Alzheimer’s Australia.

Access Economics, 2005, “Dementia Estimates and Projections-Australian States and territories”, Report prepared for Alzheimer’s Australia.

Access Economics, 2006, “Listen Hear! The Economic Impact and Cost of Hearing Loss in Australia”, Report prepared for the Cooperative Research Centre for Cochlear Implant and Hearing Aid Innovation and Victorian Deaf Society.

Access Economics, 2009, “Making Choices-Future Dementia Care: projections, problems and preferences”, report prepared for Alzheimer’s Australia.

Aged Care Price Review Taskforce, 2003, “Investing in Aged Care”(Hogan Report). See www.health.gov.au/investinginagedcare/index.htm.

Ageing Population Panel, 2000, “The Age Shift-Priorities for action”, Department of Trade and Industry, London.

AIHW 2008, “Australia’s Health 2008”, Australian Institute of Health and Welfare, Canberra.

Alwyn, M, Wiley, D and Nobel, J, 2007, “State of Technology in Ageing Services”, Interim Report submitted to Blue Shield of California Foundation, Center for Ageing Services Technologies, Washington.

APEC CTF, 2003, “DNA Analysis for Human Health in the Post-Genomic Era”, APEC Center for Technology Foresight, NSTDA, Bangkok.

APEC CTF, 2008, “Roadmapping Converging Technologies to Combat Emerging Infectious Diseases”, APEC Center for Technology Foresight, NSTDA, Bangkok.

ATSE, 2007, “The Technological Implications of an Australian Population of 30 Million by 2050”, Australian Academy of Technological Sciences and Engineering, Melbourne.

Bainbridge, W S and Roco, M C (eds), 2006, “Progress in convergence: technologies for human wellbeing”, Annals of New York Academy of Sciences 1093, New York.

- Bibby, P, 2010, "AUSTRALIA 2050 ... but it's a future that we can't afford", Sydney Morning Herald, 6-7 Feb.
- Bouma, H et al, 2009, "Gerontechnology as a field of endeavour", Gerontechnology, Vol. 8, No. 2, pp68-75.
- Bowes, A, and Mc Colgan, G, 2006, "Smart technology and community care for older people: innovation in West Lothian, Scotland", Age Concern Scotland, Edinburgh.
- Broekens, J et al, 2009, "Assistive social robots in elderly care: a review", Gerontechnology, Vol. 8, No.2, pp94-103.
- Compano, R et al, 2006, "Converging applications for active ageing policy", foresight, Vol. 8, No. 2, pp30-42.
- Compano, R, 2008, "Brain-Machine and Brain-Computer Interfaces: A New Way of Interaction for the Ageing Population?", manuscript submitted for publication, provided by author.
- Carmichael, M, 2009, Private Communication
- CDC 2008, "Caring for the Future-the impact of technology on aged and assisted living", Copper Development Centre Australia, Sydney.
- CRC for Construction Innovation, 2004, "Way-finding in the Built Environment", see www.construction-innovation.info/.
- Celler, B, 2009, "Telehealth Services for the Management of Chronic Diseases at Home and in the Community", see www.atse.org.au NSW Division, 2009 Seminar, Impact of Disruptive Technology on Healthcare in Australia.
- Cels, 2007, "Technology to Support the Ageing Global Population 2007 to 2027", Newcastle-on-Tyne. See www.activeage.org/.
- Chan, M et al, 2009, "Smart homes-Current features and future perspectives", Maturitas, Vol. 64, Issue 2, 20 October, pp90-97.
- Charlton, J et al, 2002, "Vehicle Safety and Older Drivers", Gerontechnology, Vol. 1, No. 4, pp274-286.
- Coughlin, J F, and Pope, J, 2008, "Innovations in Health, Wellness and Aging-in-Place", IEE Engineering in Medicine and Biology Magazine, July-Aug, pp47-52.
- Collste, G, 2009, "The ethics of ambient computing for personal health monitoring", Proc. 8th Int. Conf. of Computer Ethics: Philosophical Enquiry (CEPE), 26-28 June, Corfu, Greece.
- Croll, P, 2009, "Smart homes help with health care", see www.workingcarers.org.au/.
- Dissanayake, G, 2009, Private Communication.
- Donaldson, I, 2009, Private Communication.
- Doughney, J, 2006, "Ageing and the Economy: Time for a Debate Based on Evidence", J. Business Systems, Governance and Ethics, Vol. 1, No. 2, pp1-11.
- Engineers Australia, 2008, "Policy Statement-Engineering Technology and an Ageing Population, March; Draft Policy Statement-Assessment, Prescription, Procurement and Life Cycle Support of Assistive Technologies, August; Developing a National Disability Strategy, December", Engineers Australia, Canberra.

- EURON 2004, “European Robotic Research Network (EURON) Research Roadmap”, www.cas.kth.se/euron/eurondeliverables/ka1-3-Roadmap/.
- European Commission, 2006, “European Technology Platform on Nanomedicine; Nanotechnology for Health-Strategic Research Agenda”, Luxembourg, pp39.
- Department of Education Science and Training (former), <http://www.dest.gov.au/NR/rdonlyres/AF4621AA-9F10-4752-A26F-580EDFC644F2/2846/goals.pdf>.
- European Commission, 2007, “Biomaterials for Health Care: a decade of EU-funded research”, EU 22817.
- Franchimon, F, and Brink, M, 2009, “Matching technologies of home automation, robotics, assistance, geriatric telecare and telemedicine”, *Gerontechnology*, Vol. 8, No. 2, pp88-93.
- Giles, L C, et al, 2003, “Disability in Older Australians: projections for 2006-2031”, *The Medical Journal of Australia*, Vol. 179(3), pp130-133.
- HMIC, 2008, Home Modifications Clearing House, University of New South Wales www.homemods.info/.
- Iliffe, J, 2007, “A New Approach to Australia’s Health Workforce”, Centre for Policy Development, www.cpd.org.au.
- Johnson, G, et al, 2008, “Technology” in AGEACTION: Changing expectations of life, EU FP6 Framework, April 2007, pp.89-104, http://ageaction.ncl.ac.uk/AgeAction_book.pdf.
- IEEE, 2009, International Conference on eHealth, Telemedicine and Social Medicine (eTELEMED 2009), Cancun, Mexico, Conference Publishing Services, Los Alamitos, California.
- Krebs, H L, et al, 2008, “A Paradigm Shift for Rehabilitation Robotics”, *IEEE Biology and Engineering Magazine*, July/August, pp61-70.
- LISF, 2008, “Investing in the Future: An Assessment of the Returns to Investment in Health Innovation”, Framework Paper, Life Science Innovation Forum VI, August, Lima, Peru.
- Lawes, A. 2010 “Invasion of the scooters”, *Sydney Morning Herald*, Feb.26, Drive Life pp6-7. See www.drive.com.au.
- Lovell, N, 2010, “Telehealth technology to manage chronic disease”, *ATSE Focus*, No. 160, Feb, pp30-31.
- Marotolli, R, 2009, “Safe Mobility for Older Persons”, *The Bridge*, Vol. 39, No. 1, pp27-33.
- MBA, 2009, “Housing for Life”, Master Builders Association of the A.C.T. See www.mba.org.au.
- McCreadie, C, 2005, “Older pedestrians, mobile phones and new way-finding technology; first stage of new research”, *Gerontechnology*, Vol.4, No.1, pp5-14.
- Meyer, J, 2009, “Designing In-Vehicle Technologies for Older Drivers”, *The Bridge*, Vol.39, No.1, pp21-26.
- Moulton, S E, and Wallace, G G, 2008, “An introduction to nanobionics”, *Materials Australia*, Aug, pp22-23.
- NAE, 2009, see several papers on technology and ageing in the Spring issue of *The Bridge*, Vol.39, No.1.
- NAF, 2006, “Environmental, Social, Legal and Ethical Aspects of the Development of Nanotechnologies in Australia”, National Academies Forum for the National Nanotechnology Strategy Taskforce, Canberra.

- NATF, 2008, "Le Patient, les Technologies et la Medecine Ambulatoire", Academie des Technologies, Paris. See <http://www.academie-technologies.fr/fileadmin/templates/PDF/Publication/Patient.pdf>.
- Nordmann, A, (ed), 2004, "Foresighting the new technology wave: converging technologies-shaping the future of Europe", European Commission, Brussels. See www.cordis.lu/foresight/nfw_conf2004.html.
- Pagan, J D, et al, 2008, "Getting Creative in Healthcare; The contribution of creative activities to Australian healthcare", Technical Report, Creative Industries, ARC Centre of Excellence for Creative Industries and Innovation, Queensland University of Technology, Brisbane.
- Parker, L, 2010, "Gene testing – what it means for your insurance", Sydney Morning Herald (Money) , March 3, pp4-6.
- PMSEIC, 2003, "Promoting Healthy Ageing in Australia", Prime Minister's Science, Engineering and Innovation Council, Canberra.
- PMSEIC, 2005, "Nanotechnology: Enabling technologies for Australian innovative industries", Prime Minister's Science, Engineering and Innovation Council, Canberra.
- Pond, S, 2010 "The biotechnology revolution-delivering personalised medicine", ATSE Focus, No. 160, Feb, pp5-7.
- Productivity Commission, 2005, "Economic Implications of an Ageing Australia", Canberra.
- Productivity Commission, 2008, "Trends in Aged Care Services; some implications", Research Paper, Canberra.
- QSHI, 2006, Queensland Smart Homes Initiative. See www.qshi.org.au.
- RAE, 2007, "The Ageing Population: Challenge for Engineering", Policy Paper, Royal Academy of Engineering, London.
- Ruoppila, I, et al, 2003, "The MOBILATE cohort study 1995–2000: enhancing outdoor mobility in later life". See www.dzfa.uni-heidelberg.de/english_version/asoeg/m-mobilate.html.
- Roco, M C, and Bainbridge, W S, (eds), 2003, "Converging technologies for enhancing human performance", Kluwer, The Netherlands.
- Rose, D, 2009, "More heat-related deaths likely", Sydney Morning Herald, 25 March.
- Schmidt, K F, 2007, "Nanofrontiers: Visions for the Future of Nanotechnology", Woodrow Wilson International Center for Scholars, Washington, D.C.
- Shepherd, R, 2010, "Medical bionic technologies-the next generation", ATSE Focus, No. 160, Feb, pp32-33.
- Sintchenko, V, 2010, "Informatics-the future of medicine", ATSE Focus, No. 160, Feb, pp21-23.
- Sixsmith, A, 2002, "UK Policy on New Technology to Support the Independent Living of Old People", Gerontechnology, Vol. 2, No. 2, pp206-210.
- Taha, T, et al, 2008, "POMDP-BASED Long Term User Intention Prediction for Wheelchair Navigation", 2008 IEEE International Conference on Robotics and Automation, Pasadena, 19-23 May, pp3920-3925.
- The Benevolent Society, 2009, "Apartments for Life in Australia: Lessons from Humanitas in the Netherlands", The Benevolent Society, Sydney.

- The Economist, 2009, "Medicine goes digital: a special report on health care and technology", 18 April.
- Thorleifsson, G, et al, 2007, "Common sequence variants in the LOXL1 gene confer susceptibility to exfoliation glaucoma", Science, Vol. 317, pp1397-1400.
- Tiedemann, A, et al, 2008, "Hospital and non-hospital costs for fall-related injury in community-dwelling older people", NSW Public Health Bulletin, Vol 19, (9-10), p161.
- Treasury, 2007, "Intergenerational Report 2007". See [www.treasury.gov.au/igr/IGR 2007.asp](http://www.treasury.gov.au/igr/IGR%2007.asp).
- Treasury, 2010, "Intergenerational Report 2010". See www.treasury.gov.au.
- Van Hoof, J, et al, 2007, "Ambient intelligence, ethics and privacy", Gerontechnology, Vol. 6, No. 3, pp155-163.
- Van Hoof, J, et al, 2009, "Housing and care for older adults with dementia; a European perspective", J. Housing and the Built Environment, Vol 24, pp369-390.
- Victorian Government, 2007, "Preventing Falls in Victoria 2007–2012", discussion paper, Aged Care Branch, Department of Human Services.
- Vos, T, et al, 2006, "Projection of health care expenditure by disease: a case study from Australia", background paper for UN World Economic and Social Survey 2007; Development in an Ageing World.
- WHO, 2004, "Glaucoma now second leading cause of blindness", Bulletin of the World Health Organization, Vol. 82 (11), pp811-890.
- Winslow, R, 2010, "Illumina unveils system to cut genome sequencing costs", Wall Street Journal, 12 Jan. See <http://online.wsj.com/article/SB10001424052748704586504574654712910204336.html>.

SMART TECHNOLOGY FOR HEALTHY LONGEVITY

APPENDIX A

Outputs from the ATSE Questionnaire and Workshops

THE ATSE QUESTIONNAIRE

As a starting point, the Chair of the Steering Committee circulated a short questionnaire in mid-2008 to Fellows to seek their views on three issues:

1. Is there anything currently on the market (anywhere in the world) that you would buy for yourself or someone that you know if it was cheaper or available through health insurance which would improve health and well-being and reduce risk?
2. Are you aware of any technologies employed in other areas which could be adapted for use in the home?
3. Is there anything you can think of that is not currently available but if it were, it would make you or people you know, healthier, safer and happier?

RESPONSES

Some 30 Fellows responded with a wide variety of very useful comments as follows:

1. Currently available technologies.

Security: Tele-med devices for remote health monitoring, reflex assessment, tracking and falls.

Independence: Audio GPS for visually impaired, easily used mobile phones, Skype conferencing, improved sleep technology, improved hearing aids.

Mobility: Stair climbing equipment, ultra-light wheelchairs, friendlier GPS for driving.

2. Possible technologies

Security: Implants for health monitoring, smart homes with remote video sensing and controls.

Independence: Smart homes with intelligent appliances and ability with voice recognition to order services as needed and maintain healthy diets.

Mobility: Safer transport vehicles.

3. Suggestions for new technologies

Security: Better devices for medication compliance, fall alleviation (airbags), sleep monitoring.

Independence: Improved Internet systems for emotional and intellectual engagement, intelligent cards for handling payments, easy opening closures on food containers, improved vision and hearing devices.

Mobility: Handling devices for people of limited mobility, enhanced sensors for older drivers.

These responses are very much in line with the view that there is a lack of knowledge of existing technology in that many of the products and technologies suggested are available today but are not being used. Within the time horizon of this study, much of the new assistive technology will be based on existing capabilities. However major breakthroughs and/or development of existing platforms and infrastructure will be necessary, for example increased lifetimes for power cells, energy-harvesting technologies such as electrostatics, integrated and pervasive sensors and miniaturisation of components.

ISSUES ARISING IN THE WORKSHOPS

Workshops involving Fellows and experts were held in Brisbane, Melbourne and Sydney. The issues raised in the workshops are summarised below. These have provided a valuable input to the preparation of the report and the support of the participating Fellows is gratefully acknowledged.

BRISBANE, 5 MAY 2009

Held at University of Queensland, chaired by Prof. Gordon Dunlop FTSE.

Main points made were:

Australian Health System

- Lack of coordination between State and Federal systems.
- Number of successful groups and companies working in isolation.
- Poor medical records system – even within same city, GPs and hospitals are not linked; need national approach.
- States have vested interest in developing monitoring and maintaining people at home since hospitals are very expensive.
- About 150,000 people in institutional care – number to increase substantially in future.
- Increased dementia a major problem – would be a massive breakthrough by delaying cognitive impairment (delay of onset by five years reduces number by 50 per cent). Note dementia trial in progress – Peter Hudson has report.
- Where will carers come from as active/aged ratio decreases. Could be by increased migration BUT strong case can be made for increased use of monitoring.

Technology Availability

- Monitoring not technically difficult – overseas companies are involved in major trials.
- What about Australia? Some companies working in field and lots of research with some trials but little overall knowledge of what is happening. A list would be useful since there were several calls for more large trials (a delegation from Queensland is going to look at trials in UK soon – major one in West Lothian with 5000 people).
- Strong emphasis on ubiquitous computing and telehealth-monitoring by systems of sensors can be more dependable than carers – can check on changes of pattern and habits and can track wandering dementia patients.
- Mobile phones can play a very useful role for assisting monitoring by carers if design is suitable for aged people.

Acceptability

- Technology must be functional, useable and friendly.
- Connectivity with family and social group is very important – personal contact a vital factor-linked to mobility.
- Clinical outcomes must be as good as or better than with carers, for example increased sense of security.
- Essential to define user needs – aged people find problems with increasingly complicated service provision and dealing with utilities – more systems, more things to hassle them! Also impersonal nature of computing linkages difficult to accept.
- Intergenerational differences discussed – probable that next generation will be more accepting of technology solutions but some will still have problems.

Audience for Report

- Variety of suggestions – aged care lobby groups seen as important.
- Government clearly important – pitch on savings and an innovative industry.

MELBOURNE, 12 MAY 2009

Held at University of Melbourne, chaired by Dr Paul Donaghue FTSE.

Main points made were:

Australian Health System

- Intense activity on health issues by Australian Government – National Health and Hospitals Reform Commission (latest report covers themes of Taking responsibility; Connecting care; Facing inequities, and Driving quality performance) and Preventative Health Task Force (covering obesity, tobacco, and harmful consumption of alcohol) but little mention of technology.
- Lack of coherence in Federal/State Government approach to aged issues. National Council on the Ageing working at State levels on local issues, some websites have useful technical information, for example for older road users.
- Needs to be a clear policy on ageing-in-place as part of ‘continuum of care’ (home, independent apartment living, skilled nursing facility and 24 hour care unit) and a national technology/ageing agenda.
- Government has problems with dual role of regulator and funder – often dysfunctional relationship.

Role of Technology

- Some ambivalence on role of technology in dealing with aged people – is it aimed primarily at disabilities or at independence? Biomedical engineers see assistive technologies applicable across all ages, for example bionic ear. Technology for aged needs to be linked to communication and mobility.
- Impending shortage of carers emphasised (Alzheimer’s Australia recent report states that, given the rapid anticipated growth of dementia, 234,000 in 2009 to 465,000 by 2030, a shortage of about 150,000 paid and unpaid carers by 2030). Since about 60 per cent of dementia patients live in the community, technology in various ways can be used to improve carer situation.
- Role of informal carers important in maintaining social interaction – technology cannot substitute for personal interaction.
- Do we understand triggers of change in altering the position on the continuum of care, for example falls appear to very significant? How can we develop technologies to avert the triggers of change? Can technologies be used to prepare people for changes?
- Analysis of costs and benefits of low tech interventions appears to be lacking. What about falls prevention? Need to look at what has been done on telehealth. Caution – in new health technologies, the unit cost of care may be reduced but overall the expansion of treatment may outweigh any unit cost reductions.

Future Directions for Technology

- Essential to define what is available now and what is lacking. Why is available technology not being adopted?
- It is critical to define user needs in order to define new areas for R&D but lack of information makes decision-making difficult. Necessary to provide information to aged care groups to assist them.
- Researchers need to put forward ideas to stimulate them – converging technologies offers new approaches to the challenge of increasing elderly.
- Massive growth in assistive technologies in USA and Europe – what can we learn from them?
- Smart homes a reality but expensive – how can we better embed technology into existing houses?
- Voice recognition technology needs to be evaluated for ageing applications.

Industry Opportunities

- Outstanding examples in Australia are ResMed and Cochlear – both dealing with disabilities across wide age range. What can we learn from Access Economics case study on hearing loss in 2006? Earlier

report on vision in 2002 highlighted a major economic impact and cost – potentially large market identified – large consortium put together, Australian Government has responded with \$50 million grant again aimed at disabilities. What can we learn from this example?

- Can we identify SMEs in technology aids area and learn from them? Appear to be many small companies – fragmented approach. No large companies as in Europe and USA in large markets covering telehealth, medical devices, diagnostics.

Audience for Report

- Appears to be need for a scoping study to inform people in general to put pressure on politicians – carers have as much to gain as aged people!
- Aged – care lobby groups need to be briefed to build on public opinion.
- Senior Government officials need to be briefed with clear recommendations for action; learn from Bionic Eye activity – emphasise benefits (and costs!) particularly in relation to carers.

SYDNEY, 26 MAY 2009

Held at Garvan Institute, chaired by Mr Richard Kell FTSE

Main points made were:

Australian Health System

- Lack of coordination between Commonwealth and State systems highlighted.
- Problems of cooperation between different groups of health care professionals – very compartmentalised.
- ATSE needs to be aware of such frictions and idiosyncrasies when considering policy issues.
- Cooperation essential across disciplines vital – concept of converging technologies needs to be embraced by research funders, joint NHMRC/ARC funding for projects is essential.

Technology Acceptability

- Antagonism of nursing profession to change which might affect status and change their special role hinders introduction of new technology
- Questions over reliability of systems – problems with earlier systems make it difficult to get acceptance of newer systems.
- Essential to understand user needs and to involve healthcare workers in considering applications – empowerment of elderly is critical.
- Need to involve ethnographers and anthropologists in studying elderly behaviour – what they say they do is often not what they actually do!
- Technophobia of elderly can be overcome if correct approach used – extensive use of computers by elderly to improve quality of life.
- Need to be aware of ethnic diversity and socio-economic status when considering trials of possible systems – Australian society very complex.
- Note that cost of meaningful trials is very high and they need careful design.
- Do not forget low tech solutions to problems – need to be aware of range of available products, existence of Independent Living Centres needs highlighting

Future Areas for Technology

- Need to recognise ubiquity of telephone – critical link point for other applications. Mobile phones are powerful devices with increasing range of possible functions (iPhone cited), vital to ensure that telecoms are involved in discussions of possible systems involving central monitoring (US companies recognise this).
- Many elderly suffer from depression – online management is a possibility (MOOD GYM at ANU cited).

- Memory is an issue for operating devices – can they be adaptive? Sensors can detect moods and needs and give feedback to operating systems, for example robots.
- What do we know about brain plasticity (also raised in Brisbane) and opportunities to promote new learning to overcome disabilities or technology of reprogramming of brain by use of implants?

Industry Opportunities

- Market is complex because of different groups among the aged, for example in monitoring, need to distinguish between preventative monitoring and maintenance monitoring. Different socio-economic groups can afford different levels of expenditure, hence different levels of complexity needed. Thus, different business models are needed for different funders and different user groups – who pays is critical to development of commercial systems from lab concepts.
- A suggested model was to carry out R&D in Australia and then commercialise in US with larger market. However different business model needed in US to Australia – can we learn from ResMed or Cochlear experience?
- Limited resources plus small market suggest that rationalisation is needed to pursue only one or two lines of development in a particular area – competition between heart pumps cited as example of disastrous approach. Conversely a unified approach (even at expense of egos!) has led to national approach to bionic eye and secured major funding.
- Suggested that we can use the smart home concept as entry point for many applications – provided that systems are compatible!
- Important to recognise that home environment with elderly people often with limited skills or with disabilities is very different to lab environment. Thus the issue of verification of measurements of medical parameters may be critical in commercialising equipment.

Audience for Report

- ATSE well regarded in both State and Federal circles – example cited of presentations to NSW politicians by ATSE Fellows, can influence events.
- Need to get to Federal Ministers – good track record with recent reports.
- Input to aged lobby groups and health industry lobby groups to support policy thrusts.
- General scoping study for information among community.

SMART TECHNOLOGY FOR HEALTHY LONGEVITY

APPENDIX B

Visits and Discussions Associated with the Study

Melbourne, May 2009

- Professor Rob Shepherd, Director, Bionic Ear Institute – medical bionics, commercialisation.
- Dr Debra O'Connor, Executive Director and Dr Briony Dow, Director of Preventative and Public Health, National Ageing Research Institute – falls prevention, Alzheimer's and dementia.
- Associate Professor Elizabeth Ozanne, Chair, Research and Graduate Studies, School of Social Work, University of Melbourne – technology and ageing.
- Professor Tony Burkitt, Electrical and Electronic Engineering, University of Melbourne – bionic eye, biomedical engineering.
- Dr Frank Vetere, Information Systems, University of Melbourne – supported social activity for older people.
- Dr Gerry Naughtin, CEO, Mind Australia – technology and ageing.

Sydney, May 2009

- Dr June Heinrich, CEO, Baptist Community Services – technology applications in aged care, visit to BCS Age Friendly Home.
- Professor Nigel Lovell, Graduate School of Biomedical Engineering, UNSW and Director, TeleMedCare – development and commercialisation of clinical health monitoring systems.
- Professor Hugh Durrant-Whyte, Director ARC Centre of Excellence for Autonomous Systems – large scale applications of robotics.
- Professor Gamini Dissanayake, Mechatronics and Intelligent Systems Group, UTS.

Brisbane, May 2009

- Professor Peter Gray, Director, Australian Institute for Bioengineering and Nanotechnology, University of Queensland – nanomedicine and stem cells.

Canberra, May 2009

- Professor Philip Davies, Population Health, University of Queensland and former Deputy Secretary, Department of Health and Ageing – policy on ageing.
- Rod Young, CEO Aged Care Association – IT in aged care.

Canberra, June 2009

- Professor John Weckert, Centre for Applied Philosophy and Public Ethics (CAPPE), ANU – ethics in health care.

Canberra, July 2009

- Ben Vincent, Director, Business Improvements, Community Programs Branch, and Arthur Gidis, Acting Director, Aged Care e-connect, Department of Health and Ageing – details of programs for aged care.

- Professor Alfred Nordmann, Philosophy and History of Science, Darmstadt Technical University, visiting CAPPE and participating in Symposium on "Converging Technologies – Some Pressing Issues" (Professor Tegart also gave a paper).

Canberra, August 2009 (at Health Informatics Society of Australia Conference)

- Associate Professor Jeffrey Soar, Director, Collaboration for Ageing & Aged-Care Informatics Research, University of Southern Queensland – smart housing in Queensland.
- Dr George Margelis, Intel Australia Digital Health Group – IT in health care.
- Dr Stuart Smith, Falls and Balance Research Group, Prince of Wales Hospital, Sydney – falls research.

Melbourne, September 2009

- Meeting with National Committee on Rehabilitation Engineering, Engineers Australia – presentation of ATSE study and discussion of NCRE policy papers.

Paris, October 2009

- EU/Australia Workshop and visits in France – discussions on wide range of topics.

Sydney, November 2009

- Professor Nigel Lovell and Professor Branko Celler, Graduate School of Biomedical Engineering, UNSW – developments in telehealth.
- Meeting on "Ageing Well – a new model for social, technological and policy collaboration", organised by Innovation X Change – several presentations on aged housing, technology and society and economic considerations, including one by Professor Tegart on this ATSE project.

Brisbane, November 2009

- Professor Perry Bartlett, Director, Queensland Brain Institute, University of Queensland – brain plasticity, ageing research.
- R&D Forum on "Innovation for Healthy Ageing, Independent Living and Community Care", organised by Queensland Department of Employment, Economic Development and Innovation – presentations and discussion on possible bid for CRC in this area by a Queensland group.

Canberra, November 2009

- Dr Kaddour Raissi, Attache for S&T, Embassy of France – ageing research in France.

Canberra, February 2010

- Mr Ivan Donaldson, General Manager, Australian Building Codes Board – future building design.
- Dr Kaddour Raissi, Attache for S&T, Embassy of France – possible bilateral cooperation on ageing research.
- Professor Elim Papadakis, Executive Director, Research Investment Branch, NHMRC – information on ageing research and possible developments.
- Ms Lynne Hunter, Adviser, Bilateral relations, Delegation of the European Commission to Australia – Europe/Australia cooperation in ageing research.
- Ms Jan Gough-Watson, Manager, Europe, Americas and Strategy Section, Department of Innovation, Industry, Science and Research – support for EU/Australia activities in gerontechnology.
- Ms Karen Curtis, Privacy Commissioner.

APPENDIX C

Programme for EU/Australia Workshop on 'Smart Technology for Healthy Longevity', Paris, October 2009

SUNDAY 4 OCTOBER 2009

1930 Networking Dinner for Workshop participants, "Chez Clément" 19 rue Marboeuf 75008

MONDAY 5 OCTOBER 2009

Venue: Salons France-Amériques, 9–11 Avenue Franklin Roosevelt 75008 Paris

0830 Workshop Registration

0900 Official Opening by Professor Alain Pompidou, President of NATF

0915 Remarks by Bruno Jarry (EuroCASE, NATF) and Greg Tegart (ATSE)

0930 Presentation: "EU Action Plan, Ageing Well in the Info Society"
Peter Wintlev-Jensen, DG INFSO Head of Sector ICT for Inclusion.

Session 1: Country papers – setting the scene (20 minute presentation, 5 minutes Q&A)

Session Chair: Professor Otthein Herzog (Germany)

1000 Presentation: "The Challenge of Ageing in Australia" Professor Greg Tegart AM FTSE

1030 Presentation "Estimation of Task Persistence, Vegetative Dissociation & Temporal Disorientation Parameters in Elderly People at Home", Professor J Demongeot, TIMC-IMAG UMR UJF/CNRS 5525 University J. Fourier Grenoble, France

1100-1130 Morning Tea

Session 2: A Framework for Application of Technology (20 minute presentation, 5 minutes Q&A)

Session Chair: Netherlands

1130 Presentation: "Healthy Ageing – A Model for the Application of Technology"
Professor Garth R Johnson, FREng, Emeritus Professor of Rehabilitation Engineering, Newcastle University; Head of Research, ADL Smart Ltd, UK.

1200 Presentation "The intersection of assistive technologies with care systems" Professor Elizabeth Ozanne, Chair, Research and Graduate Studies, School of Social Work, University of Melbourne, Australia

1230-1330 Networking Lunch

Session 3: Social and ethical issues in the Application of Technology to the Aged (20 minute presentation, 5 minutes Q&A) Session Chair: France

- 1330 Presentation: "I might be old but I still have moral rights"
Professor John Weckert, Centre for Applied Philosophy and Public Ethics, Australia
- 1400 Presentation "Professional ethics in gerontechnology: a pragmatic approach" Professor Herman Bouma, Retired; Honorary President International Society for Gerontechnology, ISG, Netherlands

Session 4: Technology for the Ageing Well (20 minute presentation, 5 minutes Q&A)

Session Chair: UK

- 1430 Presentation: "The European approach: From smart houses to ambient assisted living"
Dr Ad van Berlo, Manager R &D Smart Homes, Eindhoven, Netherlands
- 1500 Presentation: "Medical Bionics: Engineering interfaces to the human body"
Professor R K Shepherd, Director, The Bionic Ear Institute, Australia
- 1530 Presentation: "Supporting healthy ageing through appropriate use of technology"
Professor Peter Gore, MD, ADL Smartcare Ltd; Professor of Practice (Ageing & Vitality), Newcastle Univ, UK

1600-1630 Afternoon tea break

Session 4: Technology for the Ageing Well (continued) Session Chair: Professor Peter Hudson FTSE (Australia)

- 1630 Presentation: "Challenges of Dementia: improving healthy ageing through early diagnosis and intervention strategies" Professor Peter Hudson FTSE, CSO, Avipep Pty Ltd and CSIRO Honorary Fellow, Australia
- 1700 Presentation: "Longer Lives – Potential and Challenge" Professor Dr Ursula Staudinger, Jacobs University, Bremen, Germany.
- 1730 Presentation: "Gerontology Development for Disabled People" F Piètte B. Zimmer, M. Carre, UPMC& Ch. Foix Hospital, France

Evening at leisure – no formal arrangements.

TUESDAY 6 OCTOBER 2009

Venue: Salons France-Amériques, 9–11 Avenue Franklin Roosevelt 75008 Paris

Session 5: Technology for the Supported Aged (20 minute presentation, 5 minutes Q&A)

Session Chair: Netherlands

- 0830 Presentation: "Care and Technology for supporting ageing in place"
Dr Helianthe Kort, Professor, Demand Driven Care, Research Centre for Innovation in Health Care, Hogeschool Utrecht, Netherlands
- 0900 Presentation: "Assistive intelligent and robotic system"
Professors Michel Paindavoine, Burgundy University and Edwige Pissaloux, ISIR/UPMC (University Paris 6) France
- 0930 Presentation: "Telehealth Technologies in the Management of Chronic Disease and Healthy Ageing", Professor Nigel Lovell, Graduate School of Biomedical Engineering, Univ of NSW, Australia

1000-1030 Morning tea break

Session 5: Technology for the Supported Aged (continued) Session Chair: Professor Lenka Lhotska (Czech Republic)

- 1030 Presentation: "Supporting independence through electronic assistive technology"
Professor Mark Hawley, Professor of Health Services Research, Sheffield University, UK
- 1100 Presentation "Independent Living through ICT"
Dr O Stepankova, FEL Czech Technical University in Prague, Czech Republic
- 1130 Presentation: "Restoring human capabilities not only for people with chronic diseases"
Professor Michael Lawo, Centre for Computing Technology (TZI), Universität Bremen, Germany

1200-1300 Networking Lunch

Session 6: Technology for the Dependent Aged (20 minute presentation, 5 minutes Q&A)

Session Chair: Professor Michael Lawo (Germany)

- 1300 Presentation: "Healthy Housing, prevention and assistance for healthy ageing"
Dr Francesco Franchimon, BAM Technie, Netherlands
- 1330 Presentation "Technology and services at home for older and/or disabled persons. Towards a conceptual revolution?", Professor Alain Franco, CHU-Nice, France
- 1400 Presentation: "Automated homes for people with dementia"
Professor Roger Orpwood, Director, Bath Institute of Medical Engineering, UK.

1430-1500 Afternoon tea break

Session 6: Technology for the Dependent Aged (continued) Session Chair: France

- 1500 Presentation: "Chances and Limitations of Smart Housing"
Dr Reiner Wichert, Head of Fraunhofer Alliance Ambient Assisted Living, Department Head at IGD Fraunhofer Institute for Computer Graphics (IGD), Germany
- 1530 Presentation: "Knowledge-based home eServices for an Aging Europe", Professor Lenka Lhotska, Gerstner Laboratory, Czech Technical University in Prague,
- 1600 Presentation: "Smart Homes and Electronic Communities of Care"
Professor Neil Bergmann, School of Information Technology and Electrical Engineering, University of Queensland, Australia

Session 7: Opportunities for S&T Cooperation

- 1630 Bruno Jarry and Greg Tegart lead discussion on way forward/progress opportunities for S&T cooperation. Summing Up.
- 1700 End of workshop
- 1800 Workshop Delegation arrive at 4, rue Jean Rey (Residence of the Australian Ambassador)
His Excellency Mr David A Ritchie for Cocktail Party
- 1930 Conclusion of Cocktail Party.

SMART TECHNOLOGY FOR HEALTHY LONGEVITY

ATTACHMENT

Smart Technology for Healthy Longevity Economic Analysis

A report prepared for ATSE by Dr Kim Sweeney, Centre for Strategic Economic Studies, Victoria University, Melbourne

1. INTRODUCTION

The Australian Academy of Technological Sciences and Engineering (AATSE) has been successful in obtaining a grant from the Australian Research Council for a project entitled “Smart Technology for Healthy Living”. The project aims to identify those technologies that will enable seniors to stay in their own homes and maintain their independence, a process called ageing-at-home. Technologies are being examined under three headings:

1. Security and safety, for instance improved house design, smart homes, sensors and tracking systems
2. Diagnosis and treatment, for instance telemedicine, devices for compliance, rehabilitation robotics
3. Assistive technologies, for instance ultralight wheelchairs, improved vision and hearing devices, enhanced mobility systems and service robotics.

As part of this project, the Centre for Strategic Economic Studies (CSES) has undertaken an economic analysis to support the review of technology conducted by Professor Greg Tegart. This analysis looks at expected demographic changes in Australia and the characteristics of people requiring care. It provides evidence on the economic benefits of interventions to enable more people to age at home by examining four major studies. Finally it estimates potential savings to the Government from greater aged care at home using recent data on the cost and utilisation of aged care programs in Australia. It also provides estimates of the savings that could arise from preventing falls among aged people.

The key findings of this analysis are given below.

Demographic Changes and Trends

Between 2010 and 2050 the number of people aged 60 or more is expected to increase by 123.9 per cent while overall the population will grow by 54.4 per cent. The cost of providing health services as a percentage of GDP is likely to double over the same time period.

Of the population aged 60 or more, around half report that they had one or more disabilities of some kind and 41 per cent need assistance. The percentage needing assistance increases rapidly with age from 25.9 per cent for people aged 60 to 64 to 94.8 per cent for people aged 90 years and over. However the percentage of people requiring assistance with personal activities is somewhat less ranging from 14.5 per cent to 79.9 per cent. Of these latter groups, only about 18 per cent live in cared accommodation with the majority living at home.

Relevant Studies on Aged Care

There are very few studies of technology interventions to support ageing at home that provide evidence that can be meaningfully used to estimate potential savings from these types of interventions in Australia. A recent review of the literature on telemedicine for instance found that “economic evaluations of telemedicine ... remain rare and few of those conducted have accounted for the wide range of economic costs and benefits” (Davalos et al 2009).

Four case studies which are relevant to the smart technology to support ageing-at-home are summarised and the findings of these strongly suggest that significant savings to Government can accrue from technologies that enable a greater degree of ageing at home.

- (i) The “Apartments for Life” Study by ACIL Tasman of a proposal by The Benevolent Society (TBS) for an accommodation complex development in Ocean Street Bondi in Sydney directed at housing, care and support for older people. The study found that the savings for the Government associated with an “Apartments for Living” type development are \$60,000 per resident assuming a discount factor of seven per cent or \$172,000 with a three per cent discount factor.
- (ii) The Dementia Study by Access Economics for Alzheimer’s Australia on various aspects of dementia in Australia. Access Economics recommended that:
 - consumer-directed models of care should be introduced to empower consumers who wish to do so to make choices in the mix of community care and residential care services that would best meet their needs including through cash options and individual budgets managed by agencies;
 - community care be reformed so that care is calibrated to respond to the range of needs; and
 - community (including EACHD packages) and residential care services for people with dementia should be adequately increased to meet projected community demand, with enhanced consumer choice in tailoring services and ongoing consumer consultation.
- (iii) The evaluation of the West Lothian Smart Technology and Community Care program conducted in 2006 by the University of Stirling. They reported good satisfaction among older people, carers and other stakeholders, and that the program “appeared capable of supporting people with dementia to age in place”. The evaluation found that the average weekly cost of care in existing homes where technologies were installed or in newly built homes was significantly less than for residential care. The difference between residential care and the purpose built facilities was £9,620 per person per year, or A\$23,463.
- (iv) An evaluation of the US Department of Veterans Affairs’ Home Telehealth Program introduced in 2003. The study found a high level of satisfaction with the program (86 per cent) and that the cohort of veterans had a 19.7 per cent reduction in hospital admissions and a 25.3 per cent reduction in bed days of care. The cost of CCHT was US\$1,600 per patient per annum which compares favourably with the direct cost of primary care services (\$13,121) and nursing home care (\$77,745).

Estimating Potential Savings from Greater Aged Care at Home

There are a number of commonwealth Government programs providing assistance for aged care. This ranges from the Home and Community Care (HACC) program providing basic maintenance and support services to around 650,000 older people wishing to live independently at home, to residential aged care for about 160,000 people.

Residential care cost \$5,669 million in 2008-09 or about \$36,100 per permanent resident. The cost of HACC in 2007-08 was \$1,652 million suggesting a cost per client of about \$2,600. Similar calculations suggest a cost per client for Community Aged Care Packages (CACAP) of about \$9,500 and for flexible care about \$21,000.

If an older person remains in community care receiving HACC rather than being in residential care, the average savings per year for the Government is \$33,500. If the older person is at home receiving CACP or flexible care, the savings per year are \$26,600 and \$15,100 respectively.

If 10 per cent of the residential aged care population could stay in the community rather than being in residential care, this represents about 15,700 people. If they received HACC instead of residential aged care this would save the Government about \$526.0 million per year. If they received CACP or flexible care the savings would be \$417.6 million and \$237.1 million per year respectively.

Falls among older people

One of the most common health problems for older people which results in significant cost to the community is injury arising from falls either at home or in care.

The cost per fall-related injury among people 65 years and over would have been about \$11,660 in 2009-10 based on 2003-04 estimates.

In 2005-06 the estimated number of hospitalised injury cases due to falls in people aged 65 years and over was 66,800 or 2,415 per 100,000 population. Applying this rate to the population estimates for 2010, means that there are currently an estimated 72,887 hospitalised injury cases due to falls in people aged 65 years each year. The current cost of these cases is estimated to be \$849.9 million per annum.

If the number of fall-related injuries among older people could be reduced by 10 per cent through the introduction of technologies that provide better support for older people in their homes, this would reduce the cost of these injuries by about \$85 million per year.

2. DEMOGRAPHIC CHANGES AND TRENDS

Concerns about the economic consequences of an ageing population have motivated Governments and others to examine how demographic changes over the next few decades will impact on health care spending and the sustainability of Government programs to support the elderly.

Population projections

The Australian Bureau of Statistics has produced population projections based on current trends in fertility, life expectancy at birth, net overseas migration and net interstate migration (their Series B assumptions) and these show a steady increase in the shares of population accounted for by older people over the period to 2050. Against an overall increase in the population of 54.4 per cent the increase for those aged 60 or more is 123.9 per cent. However as Table 1 shows, the increase is much larger for aged groups from 75-79 and upwards. After 2020 the share for those in the aged groups 60-64, 65-69 and 70-74 stabilises while the share for those aged 75 and over rises from 6.3 per cent in 2010 to 12.3 per cent in 2050 (Table 2).

The impact of this ageing in the population has been examined by the Commonwealth Department of the Treasury in two Intergenerational Reports produced in 2002 and 2007 (Treasury 2002, 2007). In the 2007 report they concluded that the ageing of the population would lift Government spending on health care from around 3.8 per cent of GDP in 2006-07 to 7.3 per cent in 2046-47. Spending on the Pharmaceutical Benefits Scheme (PBS) would rise from 0.7 per cent to 2.5 per cent while aged care expenditure would increase from 0.8 per cent to 2.0 per cent. These projections are somewhat less than those in the 2002 report in part because of modelling done by the Productivity Commission (2005) in their report on Economic Implications of an Ageing Australia and from independent critiques of the original report (eg Access Economics 2006, Begg et al 2008).

Table 1 Population projections by age, 2010 to 2050, millions

At June	60-64	65-69	70-74	75-79	80-84	85-90	90+	Total 60 and over	Total
2010	1.211	0.911	0.712	0.553	0.510	0.232	0.100	4.230	21.991
2020	1.433	1.269	1.118	0.787	0.618	0.291	0.176	5.693	25.288
2030	1.540	1.502	1.340	1.119	1.002	0.422	0.235	7.160	28.484
2040	1.632	1.617	1.448	1.336	1.240	0.642	0.400	8.315	31.340
2050	1.939	1.799	1.541	1.448	1.369	0.805	0.568	9.469	33.959
% increase 2010 to 2050									
	60.1	97.5	116.5	161.7	168.6	246.4	465.9	123.9	54.4

Source: ABS Population projections, series B

Table 2 Population projections by age, share of total population

At June	60-64	65-69	70-74	75-79	80-84	85-90	90+	60 and over
2010	5.5	4.1	3.2	2.5	2.3	1.1	0.5	19.2
2020	5.7	5.0	4.4	3.1	2.4	1.2	0.7	22.5
2030	5.4	5.3	4.7	3.9	3.5	1.5	0.8	25.1
2040	5.2	5.2	4.6	4.3	4.0	2.0	1.3	26.5
2050	5.7	5.3	4.5	4.3	4.0	2.4	1.7	27.9

Source: ABS Population projections, series B

While these reports point to an increasing economic burden associated with an ageing population, most of the projected increase in health spending is associated with the greater use of more expensive medical technologies to treat disease, rather than the increase in the number of older people. It is only the spending on aged care where the predominant influence is the ageing of the population.

Aged people requiring assistance

In 2003 the ABS conducted a survey entitled Disability, Ageing and Carers (ABS 2004) which provides base line data on the extent of disability associated with ageing in Australia.

In that year there were 3,350,200 people aged 60 or more, representing 16.9 per cent of the population. Of these older people, some 1,722,700 (or 50.4 per cent) reported that they had one or more disabilities of some kind, although the number needing assistance was 1,384,800 (or 41.3 per cent). The percentage needing assistance increased rapidly with age from 25.9 per cent for people aged 60 to 64 to 94.8 per cent for people aged 90 years and over, as shown in Table 3.

The ABS survey examined the type of assistance required and divided this into assistance with personal activities such as self care, mobility, communications, cognition and health care (which are further described in Table 5) and other activities such as assistance with paperwork, transport, housework, property maintenance and meal preparation. These latter activities are largely those associated with people living at home. Table 4 shows that most people requiring assistance with personal activities are still at home (or in a self-care component of a retirement village) with a minority in cared accommodation. It is clear that people requiring assistance with communication (understanding self and others and being understood) and cognition or emotion (relationships, feelings, emotions, decision-making) are more likely to be in cared accommodation than those requiring assistance with other activities. These activities are the ones associated more closely with dementia and other mental conditions.

Table 3 People aged 60 and over requiring assistance, thousands

Age group	Population	Needing assistance with at least one activity	%	Needing assistance with personal activities	%
60-64	851.5	220.2	25.9	123.1	14.5
65-69	701.6	187.6	26.7	111.3	15.9
70-74	622.0	237.5	38.2	144.0	23.2
75-79	525.2	260.7	49.6	157.1	29.9
80-84	366.3	239.8	65.5	171.7	46.9
85-89	191.5	151.7	79.2	114.9	60.0
90 years and over	92.1	87.3	94.8	73.6	79.9
Total	3,350.2	1,384.8	41.3	895.6	26.7

Source: ABS 2004

Table 4 People aged 60 and over requiring assistance with personal activities by type of accommodation

Activity	Total	At home	Cared	% Cared
Self care	397.3	245.8	151.5	38.1
Mobility	538.2	392.8	145.4	27.0
Communication	147.3	42.5	104.8	71.1
Cognition or emotion	328.9	187.2	141.7	43.1
Health care	705.0	545.5	159.5	22.6
All needing assistance with personal activities	895.6	733.9	733.9	18.1

Source: ABS 2004

Table 5 Tasks associated with personal activities

Activity	Tasks
Communication	<ul style="list-style-type: none"> - Understanding family or friends - Being understood by family or friends - Understanding strangers - Being understood by strangers
Mobility	<ul style="list-style-type: none"> - Getting into or out of a bed or chair - Moving about usual place of residence - Moving about a place away from usual residence - Walking 200 metres - Walking up and down stairs without a handrail - Bending and picking up an object from the floor - Using public transport
Self care	<ul style="list-style-type: none"> - Showering or bathing - Dressing - Eating - Toileting - Bladder or bowel control
Health care	<ul style="list-style-type: none"> - Foot care - Taking medications or administering injections - Dressing wounds - Using medical machinery - Manipulating muscles or limbs
Cognition or emotion	<ul style="list-style-type: none"> - Making friendships, interacting with others or maintaining relationships - Coping with feelings or emotions - Decision making or thinking through problems

Source: ABS 2004

3. RELEVANT STUDIES ON AGED CARE

(i) “Apartments for Life” Study by ACIL Tasman

In 2009 consultants ACIL Tasman undertook an assessment of a proposal by The Benevolent Society (TBS) for an accommodation complex development in Ocean Street Bondi in Sydney directed at housing, care and support for older people. The development incorporates principles of “Apartments for Life” developed by the Humanitas Foundation in Holland and incorporated in 15 complexes in that country. The development envisages construction of 133 apartments and seven townhouses accommodating 200 residents.

The development is designed to enable residents to remain at the complex for the remainder of their lives with a target of only five per cent ever needing to progress to residential care facilities. Apartments within the complex are designed to be able to meet changing demands to accommodate wheelchairs and walkers and to reduce the risk of falls and burns and similar incidents.

The complex includes facilities to support care in the complex rather than moving to higher level residential care, in part by giving greater scope for proximity to family and friends, and mutual help among residents. Included among the facilities would be a dementia day centre and consulting rooms for health and other services. A care advisor and community development coordinator would be employed at the complex.

TBS proposes to include some units priced at a discount and subsidised rentals for local older people seeking affordable housing. In addition the complex would include open space and community services accessible to the general public.

While most of the goals for supporting people at home within the complex rely on better design principles, the proposal also makes explicit allowance for

- “Technological advances to make life easier for residents and to enable them to get help quickly, such as personal alarm systems, and
- Provision for installation of non-intrusive ways of monitoring residents’ health and wellbeing, for example, sensors to alert staff if a person has fallen and is not able to get up.”

As the proposed development contains subsidised elements such as the affordable housing and community access arrangements, ACIL Tasman evaluates the costs and benefits of the proposed Ocean Street development from the point of view of the various stakeholders involved not just TBS or the developers. They make the case that the design of the complex could lead to substantial savings for Governments and others which will not be captured as benefits for TBS and developers. These include:

- reduced demand for higher care accommodation with associated Government subsidies;
- higher levels of informal care for residents leading to less formal community care provided by Governments;
- better formal care logistics resulting in better utilisation of care workers and lower travel costs; and
- reduced accidents such as falls and burns among residents with less call on health services such as hospitalisation and doctors visits.

ACIL Tasman has estimated the total savings of \$12.0 million for the 200-person development over a 45-year period using a discount factor of seven per cent, consisting of:

- reduced demand for residential care saves the Government \$8.7 million after allowing for increased levels of community care within the complex;
- savings of \$1.7 million from a 50 per cent reduction in the number of injuries likely to occur among residents; and
- savings in logistical costs of delivering community care of \$1.6 million

With a three per cent discount factor the total savings is \$34.4 million. ACIL Tasman also calculates that the affordable housing component of the Ocean Street development would cost at least \$17 million if this were to be provided by Government instead.

In summary then the savings for the Government associated with an “Apartments for Living” type development are \$60,000 per resident assuming a discount factor of seven per cent or \$172,000 with a three per cent discount factor.

(ii) Dementia Study by Access Economics

Access Economics has conducted a series of studies for Alzheimer’s Australia on various aspects of dementia in Australia. Their report in April 2009 (Access Economics 2009) suggests that dementia research is under-funded compared to that on other chronic diseases such as cardiovascular disease and cancer. They therefore call for more research on the causes, treatment and prevention of dementia and on earlier diagnosis.

In an earlier study for the Australian Society for Medical Research (Access Economics 2008) on the value of investing in health R&D, they estimate that if the incidence of Alzheimer’s disease could be reduced by five per cent through Australian R&D, then over the period 2005–10, cumulative savings of \$195 million would be realised or \$10.3 billion over 2005-2050. On the other hand if the incidence could be reduced by 50 per cent, then over the period 2005-2010, cumulative savings of \$1.97 billion would be realised or \$104.9 billion over 2005–50. Over half of these savings would be in the health and residential care sector.

Access Economics do not consider however the role that research on new technologies in the home may have on preventing or delaying the entry of dementia sufferers into residential aged care and the associated economic benefits of this.

However in their discussion of issue that need to be addressed, Access Economics states, inter alia, that

“If community care services are to be more attractive to consumers there is a need to restructure and reform community care so that care is available to respond to the range of needs, without inflexible boundaries. There is a need also to introduce consumer-directed models of care in the delivery of care packages and respite care to enable those people with dementia and their carers who wish to do so to determine the services that would meet their needs either through cash or individual budgets. It is recommended that:

- consumer-directed models of care should be introduced to empower consumers who wish to do so to make choices in the mix of community care and residential care services that would best meet their needs including through cash options and individual budgets managed by agencies;
- community care be reformed so that care is calibrated to respond to the range of needs; and
- community (including EACHD packages) and residential care services for people with dementia should be adequately increased to meet projected community demand, with enhanced consumer choice in tailoring services and ongoing consumer consultation.

This supports the kind of development envisaged in The Benevolent Society’s “Apartments for Life” proposal. There is an obvious role for the development of technology to support ageing-at-home to better meet the needs of older people and carers in the consumer-directed models of care advocated by Access Economics.

(iii) West Lothian Smart Technology and Community Care

In 1999, the West Lothian Council in Scotland introduced its ‘Opening Doors for Older People’ initiative in order to:

provide an innovative form of housing for older people with support needs that will sustain independent living through effective physical design, focused individual care planning and the efficient use of new technologies.

As part of this initiative, the Council offered a package of technologies to be installed in existing homes including:

- a home alert console, which links sensors to the call centre when they are triggered;
- two passive infra-red (PIR) detectors to monitor activity and potential intruders;
- two flood detectors, activated by leaking pipes, overflowing baths etc;
- one heat extreme sensor, sensitive to both high and low temperatures; and
- one smoke detector.

In addition the Council built new residential facilities incorporating these and other technologies designed to assist people stay in their homes rather than have to move to residential care.

An evaluation of the program was conducted in 2006 by the University of Stirling (Bowes and McColgan 2006, 2009). In addition to reporting good satisfaction among older people, carers and other stakeholders, and that the program “appeared capable of supporting people with dementia to age in place”, the evaluation found that the average weekly cost of care in existing homes where technologies were installed or in newly built homes was significantly less than for residential care.

Table 6 shows the weekly cost of care per person in West Lothian for different types of care both in UK pounds and in Australia dollars converted at the average rate in 2006 of 0.41 pounds per Australia dollar. The difference between residential care and the purpose built facilities was £9,620 per person per year, or A\$23,463.

Table 6 Weekly cost of care per person, West Lothian, £

	Residential care	New facilities	Existing homes
In UK pounds	531	346	387
In Australian dollars	1,295	844	944

(iv) Department of Veterans Affairs’ Home Telehealth Program

In 2003, the US Department of Veterans Affairs (DVA) introduced a national home telehealth program, Care Coordination/Home Telehealth (CCHT) to provide a service that would avoid unnecessary admission to long-term institutional care by the veteran population. By 2007 this program had enrolled 43,430 veterans of a total population of about 5.6 million. Depending on the veteran’s requirements, the program provides a range of technologies such as videophones, messaging devices, biometric devices, digital cameras, and telemonitoring devices in the home.

An evaluation conducted in 2007 (Darkins et al 2008) found a high level of satisfaction with the program (86 per cent) and that the cohort of veterans had a 19.7 per cent reduction in hospital admissions and a 25.3 per cent reduction in bed days of care. The cost of CCHT was US\$1,600 per patient per annum which compares favourably with the direct cost of primary care services (\$13,121) and nursing home care (\$77,745).

4. ESTIMATING POTENTIAL SAVINGS FROM GREATER AGED CARE AT HOME

Government assistance for aged care

All levels of government provide some assistance to those older people needing some assistance with daily activities. This ranges from inexpensive services such as basic maintenance in the home to higher cost services found in residential care. Broadly speaking the support provided by the Commonwealth Government is for two settings – community care and residential care. The trends in aged care services have been recently reviewed by the Productivity Commission (2008) and the description below draws on this study and other sources.

The Home and Community Care (HACC) program serves as the mainstay of community care by providing basic maintenance and support services to older people (and some younger people) wishing to live independently at home. HACC providers offer a wide range of services including domestic assistance, meals, nursing, transport, allied health, home maintenance, personal care, social support, aids and equipment.

There were 637,521 people aged 65 years or older receiving HACC services in 2007-08 (Commonwealth of Australia 2009) with about 65 per cent of these services going to those aged between 75 and 90 (Table 7). Most HACC clients (90 per cent) received less than two hours of service each week, although a small proportion (three per cent) received more than 4.5 hours each week, some up to 28 hours each week.

Table 7 People aged 65 and over receiving HACC in 2007-08

	Number	%
65-69	64,456	10.1
70-74	94,635	14.8
75-79	138,175	21.7
80-84	158,550	24.9
85-89	118,294	18.6
90-94	48,640	7.6
95+ (4)	14,771	2.3
Total Older People	637,521	100.0

Source: Commonwealth of Australia 2009

Two programs administered by the Department of Veterans' Affairs (DVA) also assist a significant proportion of older people by offering a range of services similar to that delivered through the HACC program. The Veteran's Home Care (VHC) program provided services to around 72,100 veterans aged 70 years or older in 2006-07 while the DVA Community nursing program assisted 33 365 veterans of all ages in the same year.

The Australian Government also funds three programs designed for older people eligible for residential care but who have expressed a preference to remain in the community:

- Community Aged Care Packages (CACPs) – provide a bundle of services averaging seven hours a week as an alternative to low level residential care;
- Extended Aged Care at Home (EACH) programs – target older people eligible for high level residential care by providing an average 23 hours of packaged care a week; and
- EACH Dementia (EACHD) – designed to provide the highest level of community care for those with complex cognitive, emotional or behavioural needs.

At June 2008 there were 40,280 people receiving CACPs, 4,244 people receiving EACH and 1,996 receiving EACHD (AIHW 2009a).

Aged people with physical, medical, psychological or social care needs that cannot be practically met in the community are eligible for residential aged care. There are two main classes of residential care - low level care and high level care. Low level care covers the provision of suitable accommodation and related living services (such as cleaning, laundry and meals), as well as personal care services (such as help with dressing, eating and toileting). High level care covers accommodation and related living services, personal care, nursing care and palliative care within a fulltime supervised framework.

At 30 June 2008, there were 160,250 residents in aged care facilities of whom 157,087 were permanent residents and 3,163 were there temporarily for respite. The age distribution of the permanent residents is given in Table 8. Well over half of the residents were aged 85 or more. About 76 per cent of residents have high-care dependency levels while 24 per cent are low-care.

Table 8 Aged distribution of permanent aged care residents, Australia, 30 June 2008

Age	Number	%
<65	6,606	4.2
65-69	4,951	3.2
70-74	8,626	5.5
75-79	17,764	11.3
80-84	33,228	21.2
85+	85,912	54.7
Total	157,087	100.0

Source: AIHW 2009

The relative scale of Government support for the various components of aged care services is illustrated in Table 9 drawn from PC 2009 which shows expenditure on aged care programs in 2006-07. Residential aged care makes up the bulk of expenditure at 62.8 per cent with community care (24.6 per cent) and support for carers (11.9 per cent) being the other main contributors.

Table 9 Recurrent government expenditure on aged care programs in Australia, 2006-07

Program	\$ million	%
Aged care assessments	58	0.7
Residential aged care	5,398	62.8
Community care	2,117	24.6
HACC	1,151	13.4
CACP	381	4.4
VHC	93	1.1
Flexible care	248	2.9
Respite care	191	2.2
Information, support & other community care	53	0.6
Financial support for carers	1,018	11.9
Total	8,591	100.0

Source: PC 2008

More up-to-date data is available for residential care which cost \$5,669 million in 2008-09 (DoHA 2009) or about \$36,100 per permanent resident. The cost of HACC in 2007-08 was \$1,652 million (Commonwealth of Australia 2009) suggesting a cost per client of about \$2,600. Similar calculations suggest a cost per client for CACP of about \$9,500 and for flexible care (mainly EACH and EACHD) about \$21,000.

Based on these calculations, it can be seen that if an older person remains in community care receiving HACC rather than being in residential care, the average savings per year for the Government is \$33,500 (\$36,011-\$2,600). If the older person is at home receiving CACP or flexible care, the savings per year are \$26,600 and \$15,100 respectively.

If 10 per cent of the residential aged care population could stay in the community rather than being in residential care, this represents about 15,700 people. If they received HACCP this would save the Government about \$526.0 million per year. If they received CACP or flexible care the savings would be \$417.6 million and \$237.1 million per year respectively. Table 10 below shows the savings if the residential aged care population is reduced by differing percentages.

Table 10 Annual savings to Government from reduction in residential care numbers, \$m

Percent reduction	Numbers	HACCP \$m	CACP \$m	Flexible care \$m
1	1,570	52.6	41.8	23.7
2	3,140	105.2	83.5	47.4
5	7,850	263.0	208.8	118.5
10	15,700	526.0	417.6	237.1

Falls among older people

One of the most common health problems for older people which results in significant cost to the community is injury arising from falls either at home or in care.

The Injury Research Centre at Flinders University has estimated the incidence and cost associated with falls among the elderly (Bradley and Harrison 2007, Bradley and Pointer 2009) while Moller (2003) has projected the costs of fall related injury to older persons in Australia over the period to 2051.

Around one in three older persons living at home experience a fall annually while about four per cent of participants in the ABS Health Survey in 2004-05 aged 75 years and older reported having suffered an injury as a result of a 'low fall' in the four weeks prior to survey. A substantial proportion of these injuries result in admission to hospital.

Bradley and Pointer (2009) report that in 2005-06 the estimated number of hospitalised injury cases due to falls in people aged 65 years and over was 66,800—a rise of 10 per cent since 2003-04. Moreover the age-standardised rate of fall injury cases for older people (2,415 per 100,000 population) had also risen compared to 2003-04 (2,295 per 100,000).

The Chief Health Officer in NSW states that fall-related hospitalisations in people aged 65 and over was 2,793.3 per 100,000 in 2007-08 in that State and that this had been increasing by about four per cent per annum on average over the previous five years (NSW Department of Health 2009).

In their earlier report, Bradley and Harrison estimate that the total cost of fall-related acute episodes of care in hospitals was \$556.0 million in 2003-04. This includes the cost of the 60,497 fall injuries as well as 41,417 follow up and other fall-related separations. This implies a cost per fall-related injury among people 65 years and over of \$9,355 in 2003-04 (ie \$556 million divided by 60,497. Comparable data is unavailable for later years.

The AIHW in its health expenditure accounts (AIHW 2009b) presents both current and constant price estimates public hospital expenditure. From these an impact price deflator can be calculated and this shows that the price of public hospital services rose by about 24.7 per cent between 2003-04 and 2009-10. This means that the cost per fall-related injury among people 65 years and over would have been about \$11,660 in 2009-10 based on the 2003-04 estimates.

Applying the age standardised rate reported by Bradley and Pointer of 2415 per 100,000 people aged 65 and over in 2005-06 to the population estimates for 2010 given in Table 1 above, means that there are

currently an estimated 72,887 hospitalised injury cases due to falls in people aged 65 years each year. The current cost of these cases is therefore estimated to be \$849.9 million per annum (ie \$11,660 times 72,887).

If the number of fall-related injuries among older people could be reduced by 10 per cent through the introduction of technologies that provide better support for older people in their homes, this would reduce the cost of these injuries by about \$85 million per year.

REFERENCES

ABS 2004, Disability, Ageing and Carers: Summary of Findings, Australia, ABS Cat No 4430.0, Canberra, 2004 at <http://www.abs.gov.au/AUSSTATS/abs@.nsf/productsbyCatalogue/C258C88A7AA5A87ECA2568A9001393E8?OpenDocument>

ABS 2008, Population Projections, Australia, 2006 to 2100, Cat No 3222.0, Canberra, 2008 at <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/3222.0Main+Features12006%20to%202101?OpenDocument>

Access Economics 2006, Intergenerational Report Review, Report by Access Economics Pty Limited for Medicines Australia, 6 September 2006 at <http://www.accesseconomics.com.au/publicationsreports/getreport.php?report=95&id=130>

Access Economics 2008, Exceptional Returns The Value of Investing in Health R&D in Australia II, prepared for the Australian Society for Medical Research, Canberra, June 2008 at <http://www.asmr.org.au/Publications.html>

Access Economics 2009, Making choices Future dementia care: projections, problems and preferences, report for Alzheimer's Australia, April 2009 at <http://www.alzheimers.org.au/content.cfm?infopageid=5604>

ACIL Tasman 2009, The "Apartments for Life" Housing, Care & Support Concept for Older People, prepared for The Benevolent Society, July 2009 at <http://www.bensoc.org.au/uploads/documents/ACIL-Tasman-apartments-for-life-July-2009.pdf>

Alwan, Majd and Jeremy Nobel 2007, State of Technology in Aging Services, Interim Report Submitted to: Blue Shield of California Foundation, Center for Aging Services Technologies November 2007

Australian Institute of Health and Welfare 2009a, National Aged Care Programs, at <http://www.aihw.gov.au/agedcare/nationalprogs/index.cfm>

Australian Institute of Health and Welfare 2009b, Health expenditure Australia 2007–08, Health and welfare expenditure series no. 37, Cat no HWE 46, Canberra: AIHW at <http://www.aihw.gov.au/publications/index.cfm/title/10954>

Begg Stephen, Theo Vos, John Goss, and Nicholas Mann 2008, An alternative approach to projecting health expenditure in Australia, Australian Health Review, February 2008, Vol 32 No 1, 148-155

Bowes Alison and Gillian McColgan 2006, Smart technology and community care for older people: innovation in West Lothian, Scotland, Department of Applied Social Science, University of Stirling, August 2006, at http://www.ageconcernandhelptheagedscotland.org.uk/our_work/policy/research

Bowes Alison and Gillian McColgan 2009, Implementing telecare for people with dementia: Supporting ageing in place in West Lothian, Scotland, *Journal of Care Services Management*, January 2009, Vol 3 No 3 227-243

Commonwealth of Australia 2009, Home and Community Care Program 1 July 2007 to 30 June 2008 Annual Report, Canberra 2009, at <http://www.health.gov.au/internet/main/publishing.nsf/Content/hacc-annual-report-07-08.htm>

Darkins, Adam, Patricia Ryan, Rita Kobb., Linda Foster, Ellen Edmonson, Bonnie Wakefield, and Anne E. Lancaster 2008, Care Coordination/Home Telehealth: The Systematic Implementation of Health Informatics, Home Telehealth, and Disease Management to Support the Care of Veteran Patients with Chronic Conditions, *Telemedicine and eHealth*, Vol 14, No 10, December 2008, 1118-1126

Maria Davalos, Michael T. French, Anne E. Burdick, and Scott C. Simmons 2009, Economic Evaluation of Telemedicine: Review of the Literature and Research Guidelines for Benefit–Cost Analysis, *Telemedicine and eHealth*, Vol 15, No 10, December 2009, 933-948

Department of Health and Ageing 2009, 2008-09 Department of Health and Ageing Annual Report, Canberra, at <http://www.health.gov.au/internet/main/publishing.nsf/Content/annual-report2008-09>

Department of the Treasury 2002, Intergenerational Report 2002-03, Budget Paper No 5, Department of the Treasury, May 2002, at <http://www.budget.gov.au/2002-03/bp5/html/index.html>

Department of the Treasury 2007, Intergenerational Report 2007, Commonwealth of Australia, April 2007, at <http://www.treasury.gov.au/igr/IGR2007.asp>

Hogan W P 2004, Review of Pricing Arrangements in Residential Aged Care, Final Report, Commonwealth of Australia 2004

NSW Department of Health (2009), The health of the people of New South Wales - Report of the Chief Health Officer. Sydney: NSW Department of Health, Population Health Division at www.health.nsw.gov.au/publichealth/chorep/

Productivity Commission 2005a, Economic Implications of an Ageing Australia, Research Report, Productivity Commission, Canberra, 24 March 2005 at <http://www.pc.gov.au/projects/study/ageing>

Productivity Commission 2005b, Impacts of Advances in Medical Technology on Healthcare Expenditure in Australia, Research Report, Productivity Commission, Melbourne, 31 August 2005 at <http://www.pc.gov.au/projects/study/medicaltechnology>

Productivity Commission 2008, Trends in Aged Care Services: some implications, Commission Research Paper, Canberra, September 2008 at <http://www.pc.gov.au/research/commissionresearch/aged-care-trends>

SMART TECHNOLOGY FOR HEALTHY LONGEVITY

ATSE – in brief

The Academy of Technological Sciences and Engineering (ATSE) is an independent, non-government organisation, promoting the development and adoption of existing and new technologies that will improve and sustain our society and economy.

ATSE consists of more than 770 eminent Australian Fellows and was founded in 1976 to recognise and promote the outstanding achievement of Australian scientists, engineers and technologists.

ATSE provides a national forum for discussion and debate of critical issues about Australia's future, especially the impact of science, engineering and technology on quality of life.

ATSE links Australia with leading international bodies and worldwide expertise in the technological sciences and engineering.

ATSE fosters excellence in science, engineering and technology research and the critical education systems that underpin Australia's capacity in these areas.

ATSE tackles many of the most difficult issues governing our future, by offering fresh ideas, practical solutions and sound policy advice – and putting them on the public record.



SMART TECHNOLOGY FOR HEALTHY LONGEVITY:
Report of a Study by the Australian Academy of Technological Sciences and Engineering

© Australian Academy of Technological Sciences and Engineering

The Australian Academy of Technological Sciences and Engineering (ATSE)

ATSE Office

Level 1, 1 Bowen Crescent
Melbourne Victoria 3004
AUSTRALIA

Mail address

GPO Box 4055
Melbourne Victoria 3001
AUSTRALIA

Phone

+61 (0)3 9864 0900

Fax

+61 (0)3 9864 0930

Email

vaughan.beck@atse.org.au
bill.mackey@atse.org.au

Websites

www.atse.org.au
www.crawfordfund.org
www.cluniesross.org.au