Final Report

Health Technology Scenarios and Implications for Spectrum

Health Socio-Economic Study; Technology Scenarios Development

Ofcom

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# Health Technology Scenarios

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1 Summary

1.1 Objective of the Study

The objective of this study is to inform Ofcom of the likely future spectrum requirements of the UK’s health sector. This objective is met in three stages:

1. Illustrating a range of possible future scenarios for the health sector over the next 10-20 years, based on an understanding of its current structure and its drivers-of-change
2. Mapping the likely intersections between wireless and health technologies, and put forward a list of possible wireless health applications
3. Identifying the most likely networks to support these health technology applications, and then calculate the amount and type of spectrum that the health sector will require in the next 10-20 years.

We describe the method we have used to meet these aims in section 2.

1.2 Conclusions and Recommendations

The UK health sector: future scenarios

The health sector is likely to change significantly over the next 20 years, and its use of Information and Communications Technologies (ICT) will change faster still. This project produced a set of five scenarios to describe the health sector in 10 to 20 years time. These scenarios are an essential input to our overall project methodology, since they provide the context into which we map future applications, and understand how ICTs are likely to be used in this sector. The five scenarios, which are each described and visualised in section 4 of this report, are:

**Age of Abundance** Innovative technology solutions have enabled the NHS to consistently deliver a high quality service. The ‘centralise where necessary, localise where possible’ vision has been implemented successfully and information is widely valued and leveraged. A combination of these factors gradually delivers better health outcomes for the population so brings down the level of morbidity. This is our most positive scenario in the future of the UK health service

**Divergence** This describes a world where technological progress is high but the NHS does not make the best use of the applications available. There are pockets of innovation and change but national strategies are limited as the majority funding is consumed by the almost unsustainable wage bill. Much of the uptake and innovation of wireless ICTs in healthcare is driven by individuals, supplied by private firms and paid for outside the NHS.

**Everything in Moderation** This scenario assumes that the NHS will make some moves towards utilising available technology, but that it will largely be hampered by the lower economic growth. Whilst there are areas that will see progress and innovation, it will be at a slower rate than envisaged

**Health Service Makes Good** In this scenario we also see a largely positive scenario, where the NHS makes excellent use of available technology in order to compensate for the reduction in economic growth and funding. The rate of morbidity is still moderate due to unavoidable trends in demographics

**Stagnation** is our most negative scenario. A combination of low economic growth and technological progress lead us to a situation where the NHS is unable to deliver care at the level the public expects. There are also fears around privacy and security of information preventing major structural change and adoption of ICTs.
We consider that these scenarios are all plausible and (roughly) equally probable scenarios for the health sector in 2027. The future depends on the interplay of drivers such as the economy, individuals’ level of engagement in their own health, the structure of the NHS (and so in turn, Government policy) and its appetite and ability to harness the power of information. One of the key drivers is technology itself – from expected breakthroughs in genomic pharmaceuticals through to the supply of appropriate and affordable IT and communications technologies. The following diagram maps how these scenarios relate to the forces-for-change outlined in section 3 of this report.

**Possible ICT Health Applications**

We have identified around 50 Information and Communications Technology applications which could be used within the health sector in the next 10-20 years. These range from the administrative (sharing patient records) to the clinical (doctors’ PDAs) and include the currently dynamic telecare sector. These applications are all based on existing or foreseeable technologies, so whether or not the UK health patient of 2027 will experience them will depend largely on demand-side the factors such as the NHS budget, clinicians’ acceptance and public attitudes towards Government-held personal data.

We have grouped these applications into the areas where they will be used: at the level of the individual; in the home; in clinical settings (e.g. hospital or GP surgery) or ambulances. The full list of these applications can be found in section 5 and a detailed description of each in the Annex. To give a sample of these applications, below is the “vignette” that visualises the use of ICT applications in an ambulance and hospital setting in 10 or 20 years. This vignette comes from our “Health Service Makes Good” scenario, and therefore is a moderate account of the availability and adoption of technology in the health sector.
Vignette: Giles and emergency care

Giles Baker is driving his daughter Rachel and her two friends Jane and Sam back to University in Leeds, from their home in London. Half way up the M1 the front tyre of their small car bursts, and Giles loses control. The car spins and eventually comes to a stop, sideways on in the fast lane. Despite its collision warning system, a large white van cannot avoid slamming into the stationary car.

Rachel, sitting in the front passenger seat, has taken the least of the impact, and manages to force open the door, but realises that Sam and Jane are both trapped in the back seat. Giles is obviously in deep shock, and cannot open his door. The motorway traffic has come to a complete standstill but the emergency services are already on their way, having been alerted by Giles’ vehicle’s telematics system.

The police are the first to arrive, and as they do so send instructions to close the motorway to following traffic and set up diversions. Fire and ambulance services arrive shortly after.

The lead ambulance paramedic, John, rapidly assesses the situation. He notes that Rachel is sitting on the verge, being comforted by a number of passengers from following vehicles. The van driver has climbed out of his vehicle and is obviously shocked, but has no apparent injuries. John concentrates on the occupants of the car, and first asks everyone if they are OK, whether and where they have pain, and – to check for spinal injuries – whether they can move all four limbs.

John carries a small PDA, which immediately and automatically picks up wireless messages from the medical ‘bracelets’ incorporated in Giles’ and Jane’s watches, which identify them and give basic medical information about serious illnesses, allergies and prescriptions. Giles has the latest model, which measures his vital signs. Sam’s bracelet has been smashed and since he has taken the full force of the impact, John leans into the car and attaches a remote monitoring device to his arm.

John’s paramedic colleague, Richard, has already alerted the trauma centre at Leicester Royal Infirmary, and has given preliminary information about the accident, the number of casualties and the apparent injuries. The hospital staff send out a simultaneous alert to the accident and emergency team, surgical and anaesthetic staff, theatres, imaging, ITU and the blood bank, which is updated as further information from the accident site is received.

The information from the bracelets has automatically been transmitted to the control panel in the ambulance, and already the full electronic medical records of all four occupants of the car have been accessed and are available to Richard, formatted to give easy access to the information relevant to the emergency such as age, blood group and key illnesses.

Giles is still too shocked to speak but is breathing. John knows from the transmitted medical information that he is on a high dose of warfarin, and fearing internal bleeding his next priority is to get him out of the car and into one of the waiting ambulances. Once in the ambulance, Richard uses a hand-held ultrasound machine to check for internal bleeding, and discusses the results with the specialist at the hospital. On advice from the specialist, he checks that Giles has not recently suffered a stroke, and administers a drug to counteract the effect of the warfarin.
Sam and Jane are showing obvious signs of pain in the pelvic region, and John has given them oxygen, and attached an intravenous infusion line. The next priority is to get them out of the car. Richard has already taken a video of the car, showing the damage and the position of the occupants, because this will provide useful information about the probable extent of the injuries to the doctors waiting at the hospital. On John’s signal, four firemen move forward with cutting gear, and rapidly cut through the supporting struts to lift the roof off the car. John can now examine Sam and Jane more directly, and satisfied that there does not appear to be any obvious head or spinal injury, they are lifted out of the car and stretchered into the second ambulance.

Richard has already sent a message to the trauma centre, with the vital signs information from Giles’ bracelet and the remote monitoring devices, the quick access key to their medical records stored on the national database, and the video film of the car.

Although Rachel has no apparent injuries, she seems shocked, and John decides all four passengers should be taken to Leicester, recognising the psychological importance of keeping them together. The van driver has only superficial injuries, but he too is taken to the hospital so that he can be fully examined to ensure there are no unseen complications.

Giles is sent off in the first ambulance, with Sam and Jane following in a second vehicle, once they have been freed, with Rachel and the van driver in the third. In the ambulances all five are monitored by fixed vital signs equipment, and the data sent forward to the hospital.

On arrival at the hospital, Giles is taken straight into a treatment bay in the trauma area. His personal identity is recorded again from his watch, and this is automatically uploaded to create a new record of his attendance at the hospital. He is given an RFID enabled wristband to track his location within the hospital.

Sam is examined and x-rayed in the trauma area, and a fractured pelvis and significant internal bleeding is confirmed. The staff check the hospital information screen to see which emergency theatre is available and ask the duty surgeon and anaesthetist to come down to the trauma area to assist with the assessment.

Giles’ assessment reveals a collapsed lung, and he is given a local anaesthetic and a tube is quickly inserted into his chest through a small surgical incision so that the lung can be re-inflated.

Meanwhile, Jane’s x-ray confirms a broken collarbone, and the possibility of a minor fracture to the pelvis. The radiographer conducts a search and summons up digital copies of previous x-rays from the Whittington Hospital in London, accessed via the national database. A close comparison using enhanced digital imaging confirms the suspicion that the minor pelvic fracture is new.

Sam is taken straight to ITU, where he is attached to the full range of remote monitoring devices.
Applications mentioned in the vignette

John’s PDA connects wirelessly to the medical bracelets worn by the passengers, overriding normal access controls, to extract identity and summary medical information. The PDA automatically copies this information to the control desk in the ambulance.

The medical bracelets worn by the passengers contain identity and summary medical information, including allergies, medications and other facts that might influence a clinical decision. The bracelets can take the form of jewellery or be incorporated into a watch. Giles has a more advanced version that also monitors vital signs.

The remote monitoring device attached to Sam’s arm measures vital signs.

Emergency ambulances are equipped with a control panel that acts as an information centre for on-board monitoring devices, and a communications link to medical record systems and destination hospitals.

Ambulance staff have automatic access to full electronic medical records which are downloaded, formatted so that the essential information which may be required in an emergency is easily accessible.

Hand held ultrasound is a portable hand-held machine. Ultrasonic waves and their echoes produce images of organs and
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systems inside the body. As technology has improved, smaller handheld devices that produce good quality images are being developed. Ambulance staff will have had specialist training in the use of the ultrasound.

Information forwarded to the hospital includes the quick access key to the patients’ full medical record, to save time in verifying identity.

The fixed vital signs equipment in the ambulance allows for constant monitoring of a patient’s condition to indicate any change during the journey to the hospital. It is automatically connected to the patient’s record.

RFID bracelets and tags allow patients and staff to be located and tracked in the hospital.

Enhanced digital imaging simply allows digital x-rays taken at different times to be digitally compared to highlight changes.

Networks and Implications for Spectrum

The vast majority of these ICT applications are supported by public and private-third party networks (including several licence-exempt spectrum technologies), such as wireless LANs, cellular telecommunications networks and RFID. In most cases, the impact of health applications on these networks is small. However in a few cases of high-density and high-data rate communications (for example, several ambulances at the same site all sharing video imagery with the local A&E unit), health-specific applications could cause congestion on these shared networks.

There are several common and important health ICT applications which may require dedicated spectrum. Applications that fall into this category are body area networks for monitoring vital signs and / or administering drugs; links between body area networks and other equipment; and social alarms for monitoring patients at home.

Given this situation and our analysis, we recommend that Ofcom should:

- Be aware that for all scenarios except Stagnation there is a requirement for new dedicated spectrum to support critical data links in hospitals, with respect to ambulance operations and at other health centres.
- Monitor the situation with respect to the utilisation of existing spectrum allocations for medical implants and social alarms. It is considered that existing allocations are adequate but there is a small risk of congestion in the most positive scenarios (Age of Abundance and Health service makes good), and, for social alarms in the most negative scenario (Stagnation).
- Note that there is a consequent knock-on effect to third party networks and systems that use spectrum commons. Any requirement for additional spectrum, which is only likely to arise with the widespread and heavy use of high quality video links, would be expected to be made through the usual channels.

For the sector to realise the benefits of ICTs, the health sector (public and private providers and patient-representation) and the technology and telecommunications industry must work closely together. There may be a case for a task-force to bring together the stakeholders, to monitor use of health ICTs and spread “best-
practice” examples of its use, and to collaborate to overcome the barriers which may hold back the sector’s technology development.

We recommend that the Department for Health (DH) should take more active responsibility for the use and management of radio spectrum by the health sector (and particularly by the NHS). This could involve the establishment of an organisation within the DH or the NHS to oversee and co-ordinate the use of spectrum, and more widely, all information and communications technologies. Such an organisation would represent the NHS’s (and ultimately of course, the patient’s) interests in order to bring about the optimal use of wireless technologies.
2 Approach

This section explains how this work has been carried out. Section 2.1 explains the Scope and Definitions; section 2.2 explains the methodology, section 2.3 the research tools used and section 2.4 introduces the project-team.

2.1 Scope and definitions

We have defined “health” widely as all activity related to health and wellbeing. Therefore it includes all formal provision of healthcare (the National Health Service and private-sector providers), as well as informal or individual preventative care or self-care and discretionary healthcare. Where health care and social care intersect (for example in the provision of telecare services to older people) we have included this in our scope. We have used the phrases “the health sector” and “healthcare” interchangeably.

Because Ofcom regulate spectrum within the whole of the UK, this report covers healthcare within England, Scotland, Wales and Northern Ireland. There are differences within the structure and policy of the NHS in Scotland, Wales and Northern Ireland – these have been described where significant but the situation in England has been used as the basis for our study. We believe this England-centric approach is justifiable, given England has the largest population and has made significant investments into the National Program for IT.

We break down health technology into three types:

- **Information and communication technology (ICTEC)** – all information and communication technologies relevant to the healthcare sector
- **Genomic and proteomic technologies, gene and antisense therapies (GENTEC)** – all technologies that are based on the application of genetic or genomic information
- **Medical devices and biomedical technology (MEDTEC)** – all other technologies which are used in the course of medical and biomedical processes and procedures

For the purpose of this report we take account of the possible developments in all three areas, keeping our focus upon on ICTEC applications that could be supported by wireless transmission.

2.2 Project Structure and Methodology

Our method can be simply described as follows:

1. Forecast the nature of the health sector in the next 10-20 years time
2. Describe the ICT applications which may be in use in the health sector in the next 10-20 years time
3. Based on this description of the applications and the context in which they will be used, offer a viewpoint on the technologies, networks and consequent implications for spectrum

Accurately predicting the health sector and its use of ICTs for such a long-term horizon is obviously not possible. Instead, we produced a set of alternative scenarios, which derive from our understanding of drivers (and barriers) of change. Today’s “start-point” is described in the Situation Analysis in the accompanying appendix, which was also one input for our long-list of ICT applications. This is shown in the following diagram.
The first step is to produce a clear version of the current situation of the health sector and its use of information and communications technologies. This is the Situation Analysis (annex A). It describes the current state of the health service within the UK, covering the health status of the population; policy and funding of the health service; structure of the health system and the supply chain; provision of health services and social care; healthcare technology. It informs two of the most important parts of our work: the Scenarios and the long-list of ICT Applications.

The other inputs to the generation of the Scenarios are the Super-Forces and the Shocks. These are all the factors which could take us from “today” to any of the five scenarios that describe a future of the health sector in 10 to 20 years time. The Forces for Change section (section 3.4) contains six “super-forces”, which in turn derive from a longer list of drivers and barriers (annex C). The main method for originating scenarios is to understand how these forces might impact the current situation.

Whereas these super-forces are evolutionary (gradual effect and grounded into today’s situation), the shocks are defined as revolutionary. Section four describes the scenarios in more detail and examines the impact of the shocks upon the inter-relationships between the super-forces and the resulting changes to the scenarios.

Section 5 seeks to provide an exhaustive list of all the possible ICT applications which might be adopted within the health sector in 10 to 20 years time. This list is organised into 4 locations, which reflect geographical areas where the applications might occur: the individual, the home, the ambulance and fourthly the fixed clinical environment (principally GP surgeries and hospitals).

It is at the next stage, “Characteristics and Usage of ICT Applications”, where the two main areas of work (Scenarios and Applications) come together. Here we estimate which applications are likely to occur in each scenario, and the extent to which they might occur. This section is structured around the list of applications, organised into the 4 locations.
The next stage (section 7) describes the networks and spectrum required to support the ICT applications that are described in each of our five scenarios. It starts with an extensive description of the maximum possible requirement for networks and spectrum. It then compares each of our five scenarios against these “Maximum Spectrum Implications”. This section focuses on the networks and spectrum that will be needed to support these applications, identifying where public or private third-party networks or unlicensed spectrum will be used and highlighting several applications which are likely to require dedicated spectrum.

Thus, having reached a view on the network and spectrum implications of each ICT application area in each of the possible scenarios, we are able to give an overall answer to Ofcom’s question.

A more detailed account of the methodology for each stage can be found in the introductory sections of each chapter.

2.3 Research tools

A mix of research techniques was used within this project:

1. Desk research on published and news sources
2. Literature Review – see bibliography, section 9
3. Interviews with experts – health, technology and futures experts - see annex B for a list of interviewees
4. Internal workshops / brainstorming sessions
5. External workshops – see appendix A for a list of attendees
6. Qualitative end-user research “Vox Pop” videos available at www.ofcom.org.uk/xxxxxx
2.4 The team
This work is the output of a multi-disciplinary team each with a different area of expertise:

**Organisation of the project team**

Harry Hobson  
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?What If!

?What If! Digital (formerly Fathom Partners) is a strategic innovation firm, focusing on health, telecommunications and technology, and is part of the ?What If! Group. The firm helps clients develop new products and services, solve business problems and improve operations. ?What If! Digital combines the rigour of strategy consulting with hands-on experience in technology, marketing and operations and an ability to think creatively, to bring clients a fresh perspective.

**Harry Hobson** is Head of Digital at ?What If! and was the co-founder of Fathom Partners, with 12 years of experience of consulting and research in the Technology, Media and Telecommunications (TMT) sectors. He heads up ?What If! Digital's Health Practice and specialises in managing and sponsoring projects on commercial strategies, innovation, marketing-strategy and organisational change.

**Alasdair Liddell** is an independent expert on the health sector. He acts as an associate of ?What If! Digital, closely involved in ?What If! Digital's Health Practice. He is also a Senior Associate at the King's Fund; is a Director of an Aim-listed health sector Plc; a former Director of the UK E-Health Association, and acts as health advisor to a number of technology and service companies. He was previously national Director of Planning for the NHS, with Board-level responsibility for IT and
Information services. Alasdair was awarded the CBE in the Queen’s Birthday Honours 1997 for services to the NHS.

**Tiffany Beale** is a consultant at ?What If! Digital. Tiffany has worked on a number of projects for telecoms providers as well as technology companies, including work for a major international telecare provider. Concurrently to this project Tiffany has also worked for NHS Choices, building on her expertise of the healthcare and technology sectors. Prior to joining ?What If! Digital’ Tiffany worked at Accenture where she gained extensive experience of project management and change management within the public sector.

**Imperial College**

**Professor James Barlow** is a Professor of Technology and Innovation Management at the Tanaka Business School, Imperial College London and is a Co-Director of the Health and Care Infrastructure Research and Innovation Centre (HaCIRIC). James’ research focuses on the structural and organisational challenges to the adoption of innovations in complex sectors of the economy, especially healthcare and construction. He has extensive experience advising government and industry on policy and innovation issues in these industries. James is a member for the Department of Health’s Telecare Advisory Network and chaired its working party on the evidence for telecare benefits. He is also a member of the Royal Society of Medicine’s Telemedicine and eHealth Council.

**Dr. Richard Curry** is a consultant specialising in telemedicine and telecare. He is currently Scientific Advisor to the Department of Health’s research initiative on the role of technology in supporting chronic disease management, self care and healthy living. He also works as a consultant to research projects on telecare based at Imperial College.

**Indepen**

Indepen is a management and economic consultancy which understands and has experience of government, regulation and investors, as well as business and other forms of enterprise. Indepen works to make business sense out of better regulation to produce better results for all stakeholders, and improved services for everybody.

**Brian Williamson is a Principal Consultant at Indepen.** Brian Williamson specialises in communications sector regulation and on the contribution that Information and Communications Technology (ICT) makes to economic growth. He also advises on radio spectrum policy and on regulation in other sectors, as well as the design of regulatory institutions and public policy appraisal, including cost benefit analysis and efficiency analysis. He has experience of working with government agencies and ministers, non-governmental organisations and investor-owned businesses.

**David Black** is a Principal Consultant at Indepen. He is an experienced economic and financial analyst who specialises in providing advice in the communications and utilities sectors. He has worked in the UK and internationally advising regulators, government departments and utilities. His experience includes advice on regulatory frameworks for electricity and telecommunications markets, market definition and competition assessment, pricing of regulated services, cost benefit and business case analysis.

**Aegis**

**Aegis Systems** is one of Europe’s foremost independent providers of specialist advice to users and regulators of the radio spectrum. Their global client base includes national governments, operators,
manufacturers, investors and regulatory bodies. Aegis’ services range from detailed engineering studies through to market analysis and client representation at international regulatory fora.

**Dr. Paul Hansell** is the Managing Director of Aegis Systems Ltd and has 27 years of experience in spectrum management issues. A large part of Paul’s career has been involved in the analysis of interference between radio systems both for regulators such as the Radiocommunications Agency, and now Ofcom, and for manufacturers and operators.
3 Derivation of the Scenarios

3.1 Introduction

As part of this project, we developed five scenarios of the health sector in 10 to 20 years time. These scenarios are an essential input to our overall project methodology, since they provide the context into which we map future applications. They are also an output of this study in their own right, as set out in Ofcom’s brief for this work: “The objective of this study is to develop future scenarios for the health sector based on potential new wireless technologies or the application of existing wireless technologies not already used in the sector.”

The scenarios are alternative, plausible accounts of what the health sector might be like in 10 to 20 years. Each is self-coherent and self-contained, and all are (roughly) equally likely to occur. From our process emerged five scenarios, named:

- Age of Abundance
- Divergence
- Everything in Moderation
- Health Service Makes Good
- Stagnation

In the next section (section 4) we explain each of the five.

This section explains how the scenarios were derived.

3.2 Overview of Methodology

There are three inputs into the scenarios:

- Situation Analysis
- Forces for Change
- Shocks

The situation analysis is a description of the current situation of the health sector and its use of information and communications technologies. It describes the current state of the health service within the UK, covering the health status of the population; policy and funding of the health service; structure of the health system and the supply chain; provision of health services and social care; healthcare technology. As an example of the Situation Analysis’s foundation for our scenario-development, in section 3.3 we give our view of today’s Key Challenges for the health sector.

The forces for change are the factors which, individually and collectively, take us from “today” to a future world where health is experienced and delivered differently. In section 3.4 we introduce the six super-forces and briefly explain how they are in turn derived from a much longer list of drivers and barriers of change.

The main method for originating scenarios is to understand how these forces might impact the current situation. In section 3.5 we show how we managed this process.

Once we had originated scenarios and tested them for internal sense and plausibility, we presented our scenarios widely to experts who could stress-test and ultimately validate them. This validation took place...
through workshops with stakeholders and experts including representatives from clinical practice, the DH, patient groups and technology firms. See annex B section 11.2 onwards for a list of workshop attendees.

Finally, we examined the effect of the shocks upon the scenarios. The shocks are introduced in section 3.6, and the way in which they affect the scenarios is then considered in more detail in section 4.8.

3.3 Key Challenges for the Health Sector (from the Situation Analysis)

3.3.1 Size and complexity

The NHS is an enormous organisation by world standards. Employing some 5.5% of the working population in the UK with a budget exceeding 8% of GDP, it provides a personally tailored service to every person in the land. This size and the sheer range and scope of the services it provides – and its public visibility and accountability – presents a formidable management challenge in ensuring it can innovate and ‘move with the times’, while at the same time deliver the highest quality of service for patients and the public, and value for money for taxpayers. The scale of this challenge is reflected in, and to some extent exacerbated by, frequent structural reorganisations as successive governments struggle to find new organisational forms to deliver improved performance. How to provide the right incentives in the right place to secure the best from a committed, but sometimes over-stressed, workforce is the question every government has wrestled with since the inception of the NHS 60 years ago.

3.3.2 An ageing population

15.8% of the UK population is over 65, and there are currently more people in the UK aged over 60 than there are children under 16. The elderly population is itself ageing: people aged 85 and over represented only 1.6% of people aged 50+ in 1951 (13.8 million), but this proportion had risen to 5.5% in 2003 (20.0 million) and is projected to be 9.1% in 2031 (27.2 million).

Older people are key users of health and social care services: in 2002/03 people aged 65+, comprising 16% of the population, accounted for 47% of total spending on hospital and community health services in England¹. The cost of an increasing number of older people who are living longer is a key cost driver for the health service.

The ageing population poses significant challenges for health and social care services, particularly around the ability of services to meet the increasing prevalence of long term conditions. An Age Concern debate in June 2007 identified four key challenges for older people in relation to healthcare: the postcode lottery in service provision, access to health care, personal responsibility and public health and specialisation and reorganisation of hospital services².

3.3.3 Changing morbidity

Long term conditions are closely allied to aging populations, changing morbidities and increasing levels of obesity. Together, these result in a significant use of healthcare resources and a high financial cost. Currently some 15 million people have a long term condition (LTC); LTCs represent approximately 50% of all GP consultations and 75% of inpatient days³.

¹ Older People, Office of National Statistics, 2005
² Building the modern NHS, Age Concern, June 2007
³ Our Health, Our Care, Our Say: A new direction for community services, Community Hospitals Association / Department of Health
The impact of the proportion of men and women who are obese or overweight is of particular concern. In 2001 over a fifth the population aged 16 and over in England was classified as obese (nearly half of men and a third of women\(^4\)). This compares with around a sixth in 1993.

Obesity is responsible for more than 9,000 premature deaths per year in England and is an important risk factor for long term chronic conditions such as heart disease, stroke, some cancers and Type 2 diabetes. The Health Select Committee has estimated that the cost of obesity alone is £3.3 - £3.7 billion per year and the cost of all those who are overweight at £6.6 - £7.4 billion. A reduction in obesity levels would ultimately lead to reductions in resultant conditions. For instance, a reduction in obesity sufferers by one million is expected to reduce the number of coronary heart disease sufferers by 15,000, the number of Type 2 diabetes sufferers by 34,000 and the number of patients with high blood pressure by 99,000\(^5\).

### 3.3.4 Technological advance

Technological advance – new drugs, new devices, new kinds of intervention, new diagnostic tools – can bring huge benefits to patients but can also represent a significant cost pressure. Even where they could deliver economic benefit over the long term – for example a drug therapy replacing the need for in-patient stay – the cost benefits are often difficult to realise in the short term. New technologies also sometimes extend the range of what the health service can do for patients, increasing the scope and therefore the total cost of the offer, albeit to the advantage of the individual.

The massive investment in NHS IT (annex A, section 8.4) is itself bringing significant cost and implementation challenges. Most of the focus to date has been on system specification and national procurement, with less attention paid to the task of local implementation – especially the changes in working practice which the new technology will enable, and which will be required to realise the full benefit of the investment.

### 3.3.5 Public expectations

Public expectations of health services are shaped by experience in other sectors, which over the last two decades have seen significant advances in a more consumerist and demanding social context. Public expectations often advance faster than the health sector’s ability to respond to them, although government in recent years has sought to improve its responsiveness. For example, a perceived public unwillingness to tolerate waiting and delay has fuelled the very strong political drive to deliver a massive improvement in access to services through the introduction of challenging targets, such as the 18 week target for delay between GP referral and treatment in hospital by 2008.

The government has also recognised that patients may want to exercise more choice about where they are treated, by whom, and when, and even to become more involved in choice of treatment options where these exist. The ‘patient choice’ initiative (enabling patients to choose their hospital of treatment from a list) is a partial response to this, although it is seen by some commentators more as a market mechanism to drive improved performance. Equally, the widespread availability of information on the internet – both about treatment options and comparative performance – is leading to more informed and therefore empowered patients.

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\(^4\) Health Related Behaviour, Office of National Statistics, January 2004

\(^5\) Health risk and costs of obesity, Department of Health, March 2007
3.3.6 Service redesign

Alongside the organisational restructuring aimed at improving NHS management (annex A, section 2.2), there is a strong move towards a more radical restructuring of the way the service is delivered. This is especially focused on evidence-based optimum patient pathways for given conditions or patient groups. This seeks to move from an institutional focus on patients’ needs to a more comprehensive focus on the total patient experience, through the ‘lifetime’ of the condition – or in the case of chronic or terminal illness, the lifetime of the patient. These approaches are based on ensuring that the right treatment is provided in the right place at the right time – for example by reducing inappropriate use of Accident and Emergency facilities, increasing the range of services provided in local settings, and restricting hospital treatment to those conditions and circumstances where the back-up of specialist skills and equipment of a hospital are genuinely required.

New service models may involve a concentration of specialist hospitals with trauma centres capable of dealing with major emergencies; a network of more local hospitals (perhaps less intensive than current district general hospitals); and the development of ‘polyclinics’ (large health centres including many GPs, together with diagnostic, urgent care and other locally based services).

These developments will require new roles for institutions and changed working practice for professional staff, and will require effective leadership to align clinical, managerial and public support behind them.

3.3.7 Funding pressures

The NHS has enjoyed substantial growth in funding during Labour’s period in government, averaging 6.6% in real terms, taking the planned total public expenditure for the Department of Health to over £100 billion in 2007-08. The growth rate is predicted to reduce to about 3.5% from 2008/09. Given the inherent growth pressures reviewed above – especially an ageing population, technology advance and public expectation – this reduction in the rate of growth will be extremely challenging.

The Wanless Report acknowledged a need for a greatly increased level of spending on the health service in the next twenty years\(^6\), while a report commissioned by BUPA predicted an £11 billion funding shortfall by 2015 which it said could lead to longer waiting lists, staff cuts and low employee morale\(^7\).

The NHS has always experienced difficulty in managing its budget performance within the very tight requirements imposed on it as a taxpayer-funded and publicly accountable organisation. In 2005-06 the NHS overspent by some £570 million, resulting in media and political criticism. The following year it achieved a surplus of around £500 million, this time met by claims that services had been unnecessarily cut back. However, to put these swings in context, they only represent around 0.75% of the budget in each year.

While hitting a precise financial year-end outturn target will continue to preoccupy financial managers, the bigger challenge will be how to manage demand within the overall budget, given the growth pressures and the reduced rate of funding growth. Bringing health inflation back into line with national inflation will become increasingly important in a publicly funded health system.

3.4 The Six Forces for Change

We have identified the following as the “Super-Forces” which are most influential in shaping the future of the health sector:

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\(^{6}\) Chapter 5: Resource Requirements, Securing our Future Health: Taking a Long-Term View, Derek Wanless, 2002

\(^{7}\) Report warns of £11 billion NHS funding gap, BUPA / NERA / Frontier, October 2006
Health Technology Scenarios

1. Economic growth and funding
2. Technology progress and rate of uptake
3. Structure of the healthcare system
4. Personal Engagement
5. Use of Information
6. Level of Morbidity

This set of “super forces” was itself condensed from a much longer list of drivers and barriers, which can be found in annex C.

3.4.1 Economic growth and funding

Economic growth and funding describe the economic climate in which the health service is operating. Supply and demand for health services increases with rising income (mainly via government expenditure). Income growth also raises the value of time and expectation of convenience for users, and raises the price of labour relative to capital. Funding not only covers the level of funding for health and healthcare generally, but also includes the level of funding specifically for technology and innovation within the NHS.

<table>
<thead>
<tr>
<th>National Economic growth</th>
<th>Public Funding for health and long term care</th>
<th>Health spending growth 2005-2025</th>
<th>Funding for innovation and technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>2.25% per annum</td>
<td>10.3% of GDP</td>
<td>108%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High proportion</td>
</tr>
<tr>
<td>Moderate</td>
<td>2% per annum</td>
<td>9.6% of GDP</td>
<td>83%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate proportion</td>
</tr>
<tr>
<td>Low</td>
<td>1.75% per annum</td>
<td>9.2% of GDP</td>
<td>59%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low proportion</td>
</tr>
</tbody>
</table>

3.4.2 Technology progress and rate of uptake

This describes the level of technological progress and rate of uptake of technology within the UK generally, including ICTs and also developments in health technology, including ICTEC, MEDTEC and GENTEC. This force also includes the rate of uptake within the health sector.
3.4.3 Structure of the healthcare system

This force describes the trend towards a ‘centralise where necessary, localise where possible’ vision of healthcare: where the provision of care polarises locally towards a concentration of highly-equipped “polyclinics” and in secondary-care towards a smaller number of high-capability specialist hospitals. Under this vision, many non-specialist “district hospitals” will have a reduced role. Highly reformed or restructured means that more primary care is provided within the home setting, with a wider range of services in polyclinics, and ‘super hospitals’ with high concentration of technology and specialist skills provide specialist services.

<table>
<thead>
<tr>
<th>Restructured</th>
<th>Partially restructured</th>
<th>Not restructured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary care is commonly provided within the home setting and polyclinics, with a reduced role for conventional ‘district general hospitals, while a smaller number of super hospitals provide specialist service.</td>
<td>Primary care is increasingly provided within the home setting but the shift to polyclinics and super hospitals is patchy and inconsistent.</td>
<td>The delivery structure of health services remains broadly as it is today</td>
</tr>
</tbody>
</table>

3.4.4 Personal engagement

This refers to the level at which people take care of their own health compared to how much they rely on the healthcare system to provide care. Included within this force is the level of disposable income that people spend on discretionary healthcare and the level of screening and self-monitoring.
### Personal engagement

<table>
<thead>
<tr>
<th>Level of disposable income that people spend on discretionary healthcare</th>
<th>Personal engagement</th>
<th>Screening and self-monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>People take responsibility for their own health and take action to maintain their health status and to self manage conditions wherever possible</td>
<td>High</td>
</tr>
<tr>
<td>Moderate</td>
<td>People take some responsibility for their health but certain factors prevent them from taking full responsibility</td>
<td>Moderate</td>
</tr>
<tr>
<td>Low</td>
<td>People do not take responsibility for their health and rely on the healthcare system to take full responsibility for their care</td>
<td>Low</td>
</tr>
</tbody>
</table>

### 3.4.5 Use of information

This covers the degree to which the healthcare system harnesses the potential of patient and clinical information and how successfully clinical and other staff capture, analyse and use data. It also includes the use of information by the public, which is partly influenced by the level of personal responsibility and partly by access to technology.

<table>
<thead>
<tr>
<th>Use of information within the NHS</th>
<th>Use of information by the public</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Information is a precious resource that is captured, collated, analysed and used to support clinical and management decision-making at every stage of care</td>
</tr>
<tr>
<td>Moderate</td>
<td>Information is collected at some stages of care, but it remains within local systems and is not extensively analysed</td>
</tr>
<tr>
<td>Low</td>
<td>The healthcare service collects some data but makes little systematic use of it</td>
</tr>
</tbody>
</table>
3.4.6 Level of morbidity

This refers to the number of people suffering from illnesses and chronic diseases.

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Increase in morbidity and disability: no healthy ageing adjustment i.e. longevity gains do not translate into additional years of good health. Level of dependency remains constant over time.</td>
</tr>
<tr>
<td>Moderate</td>
<td>Morbidity is improving and people are living longer, healthier lives but the rate of improvement is relatively slow</td>
</tr>
<tr>
<td>Low</td>
<td>Compression of morbidity and disability: longevity gains are doubled into additional years of good health. The level of dependency per age is shifted by 1 year every 10 years.</td>
</tr>
</tbody>
</table>

3.5 The Origination of the Scenarios

This section outlines the method we followed in order to understand all the ways in which the interplay of the super-forces could impact upon the current situation.

**Determine whether our view of each variable is fixed or adjustable**

For each variable there could be a number of different views that one could take. For each, we chose a position of low, moderate or high.

**Generate all possible permutations and test for plausibility**

For six variables (super-forces) and three possible permutations of each, there are a huge number of potential scenarios which can be created. The first step taken to reduce the number of scenarios was to remove all of the internally inconsistent scenarios, for example, any scenarios with both high technological progress and low economic growth were removed. We were then left with a number of scenarios, some of which are shown below.
which had only small variations, enabling us to select a representative collection of scenarios which illustrated a range of possible futures. We chose the two extremes – the most positive to the most negative and three different mid points that we believe illustrate the most likely outcomes, considering current trends and conditions within the health and technology sectors.

3.6 Shocks

A “shock” is an event which could happen in the 20-year timeframe, and which may have a significant effect upon the scenarios and our accounts of network infrastructures. Shocks exert an equivalent effect to Forces for Change (section 3.4) but are distinct from drivers and barriers because they are more sudden in their occurrence and harder to discern out of current circumstances and trends.

Some possible shocks, such as world war or meteorite strikes were suggested to us, but have not been detailed because we found their probability too low or their impact so enormous that to consider their specific effect upon health technologies would be trivial. Shocks are treated in tandem with their attendant responses. In some cases, the response to the event (or the pre-emptive preparations made to prevent or mitigate) may have as much relevant impact as the shock itself.

We have identified five shocks which will have a significant impact on the health scenarios illustrated in the following section. They are:

1. Influenza pandemic
2. Labour shortage / income level shock
3. Major data security breach
4. Major technological breakthrough
5. Major disaster e.g. bomb, nuclear accident

We have described the impact that these shocks will have on the scenarios in section 4.8.
4 The Five Health Scenarios

4.1 Introduction

The previous section has explained the purpose and the derivation of the scenarios. This section simply presents each one, and then considers how they might be affected by the impact of shock-events.

We have produced five alternative scenarios to describe the future development of the health sector. Each scenario is followed by a vignette introduces future applications and illustrate how the use of ICTs differs between each scenario.

We have called these scenarios:

- Age of Abundance
- Divergence
- Everything in Moderation
- Health Service Makes Good
- Stagnation

Each is described in detail below in sections 4.2 – 4.6. The following diagram maps how these scenarios relate to the six forces outlined in the previous section.

This diagram is for illustrative purposes only: it is a useful map of the scenarios together, not an explanation of how they were derived. Please note that we have not assumed that restructured health service, personal responsibility and use of information are mutually exclusive. It is likely, however, that where there is a highly restructured health service, personal responsibility and use of information will also be high, and our five scenarios reflect this viewpoint.
The following sections introduce each of the scenarios. For each, we show its configuration of the superforces, and then provide a clear description of the scenario, illustrated by a vignette.
4.2 Scenario 1 – “Age of Abundance”

The “Age of Abundance” shows the most positive scenario in the future of the UK health service. Innovative technology solutions have enabled the NHS to consistently deliver a high quality service. The ‘centralise where necessary, localise where possible’ vision has been implemented successfully and information is widely valued and leveraged. A combination of these factors gradually delivers better health outcomes for the population so brings down the level of morbidity.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic growth and funding</td>
<td>High</td>
</tr>
<tr>
<td>Technological progress</td>
<td>High</td>
</tr>
<tr>
<td>Structure of the NHS</td>
<td>Highly devolved</td>
</tr>
<tr>
<td>Use of information</td>
<td>High</td>
</tr>
<tr>
<td>Personal engagement</td>
<td>Moderate – rising within the 20 year timeframe</td>
</tr>
<tr>
<td>Level of morbidity</td>
<td>Moderate to Low – falling within the timeframe</td>
</tr>
</tbody>
</table>

This scenario assumes that over the next 20 years economic growth will be high at a level of 2.25% per annum and an increasing share of GDP will be invested in healthcare - 10.3% of GDP for health and long term care. This results in spending on health and long term care increasing by 108% to £215 billion by 2025. This high economic growth has precipitated conditions where the rate of technological progress has accelerated. The technology sector experiences a period of high growth, and increasing research and development resulting in the introduction of numerous breakthrough products to the health market. Standards and protocols are widely adopted within the technology community, facilitating deployment of new technologies and stimulating a global market for e-health equipment and services. Furthermore supplier relationships within the health service are simplified encouraging companies to develop medical technologies.

Within the NHS there have also been significant developments in the deployment of technology. The NHS still remains the largest employer in Europe and the potentially explosive effect of high income growth on the wage bill has been prevented with the exploitation of technologies which increase efficiency and in some cases substitute for labour. The increasing share of GDP being invested into the NHS means that there is more funding available for technology investment, and as a result technology and innovation lie at the forefront of NHS spending policy. This leads to significant developments in all areas of technology: ICTEC, GENTEC and MEDTEC as well as a shift in culture within the healthcare system towards an acceptance that risk is sometimes necessary for progress to be made. In addition NHS staff and patients not only accept technology but have come to expect it to be used within all stages of healthcare delivery. Trust in technologies is no longer a problem as their reliability and security have improved. Additionally interfaces have become highly intuitive, and clinical and administrative staff are able to use numerous new technologies with minimal formal training.

Large scale, secure and safe information sharing has been enabled by the implementation and success of information systems, such as the National Programme for IT, and communication systems, such as the fibre optic N3 project. It is commonplace for health information to be collected in real time, collated and analysed...
transforming it from information to actionable knowledge (both at the level of individual patient and at the aggregated level where information provides evidence of the effectiveness of alternative interventions to promote health, prevent illness and tackle ill-health). Vast amounts of information are available for clinicians but the quantity of information they receive is tightly regulated and the provenance understood. Healthcare has become more standardised where possible and use of systems such as the “Map of Medicine” are commonplace. Additionally, use of patient-accessible information systems is commonplace, providing patients with a wealth of information about their health.

The public rely on technology within all areas of their life. Thanks both to high economic growth and significant developments in ICT products and services, people spend a larger proportion of their income on technology. Increasingly, digital natives see ICTs as a necessity rather than a luxury and concerns about safety and privacy have been largely overcome. As people become accustomed to using particular ICTs, in particular web applications, in other parts of their lives, they come to expect similar services and applications within the health service. Peer-to-peer networks are a big area of growth further increasing the “consumer power” within the health service.

Within this scenario personal responsibility is moderate, but increasing over the 20 years. High economic growth means that people are generally wealthier, resulting in a continued upward trend in lifestyle related illnesses such as obesity. However, within the next 20 years as health information becomes more accessible and people begin to see the effects of poor health first hand there is a shift in responsibility from the healthcare system to the individual. This transfer towards the individual represents a change where the public have become more socially responsible and are willing to make sacrifices to prevent illnesses developing later in life. Developments in screening technologies and GENTEC, in particular, have increased the rate of early detection of illnesses, allowing early intervention and freeing up resources. Furthermore, people have a high level of disposable income which they can spend on discretionary healthcare products. The government and the department of health still have an influential role enabling people to make the right decisions and achieve this by improving the choices available, not only within the health system but also within areas such as nutrition and exercise.

The health service has become highly reformed; primary care increasingly takes place within the home, whilst polyclinics and specialist “super-hospitals” are reducing the role of traditional secondary care. High economic growth in this scenario has ensured that the necessary funding is available for the transitional costs needed to make changes to such a large system. Furthermore, within this scenario, health and social care have implemented systems that run in parallel to one another enabling easy transfer of information and providing a seamless service to the public. The role of the private provider within healthcare delivery has become more prominent resulting in a more competitive and efficient service. The health service has become highly personalised and doctors are able to spend longer with each individual case.

Overall, people are living longer healthier lives resulting in lower morbidity rates. High levels of funding have resulted in universal access to high quality healthcare and health inequalities have been reduced. There have been a number of breakthroughs in MEDTEC and new drugs and new drug treatments have been introduced to the market, which have made dramatic improvements in a number of previously chronic diseases. Drug therapy has become more targeted allowing morbidity to be managed more effectively. Developments in GENTEC mean that many illnesses can be identified earlier facilitating early intervention and preventing conditions from deteriorating. Developments in ICTEC allow people with chronic diseases to closely monitor their condition and prevent deterioration reducing the burden on primary and secondary care. There is an overall shift towards preventative rather than reactive care which has been facilitated by significant developments in health technologies as well as increased personal responsibility.
4.2.1 Age of Abundance Vignette

The Smith family and at-home care

The Smith family consists of Jane, who is just starting secondary school, and her parents, Andy and Jo, who are both at work. Steven, Jo’s father, is retired and lives alone some distance away.

Steven has a long term condition but wants to remain involved in his local community and connected with local friends. He is also concerned to keep as well as possible to avoid being a burden to his family and going into care. He lives in a home enabled for assisted living. One benefit of this is that he is in contact with his peer group and relatives, generally through a home hub, and can get help and information when needed. Of particular value is the live information that helps him get about the town and navigate even unfamiliar places. All this is provided to his hand-held communicator as he travels about.

Steven needs to administer warfarin for his atrial fibrillation. The correct dose is calculated for him from a blood sample placed in the home diagnostic centre via its haematology service and automatically dispensed through the dispensing unit. At the same time his INR (a measure of the clotting ability of his blood) is calculated. He recently had a hip replacement and the implanted sensor automatically reports on his gait and his mobility. Lifestyle and health advice, tailored to his individual needs, is given in the virtual clinic, supported by the on-line service and transmitted to the home hub and the hand-held communicator. The device gives a visual representation of his state of health. Of particular importance to him is the graph of his INR results. He knows that if he is on antibiotics for a while the INR can go outside the prescribed range. He can see this on his hand-held communicator and get advice on how to manage his medication and lifestyle.

Regular contact with the care services is a comfort to him and he knows that at any time he can ask for a face-to-face visit. Automatically knowing that he is up and about and that they and the care services will be automatically notified of any changes in his relative’s condition is of great comfort to the rest of the family.

Andy and Jo Smith have full time jobs. Andy had a stress related illness some years ago and is now prone to depression. His employer is very flexible and allows him to work from home when required. He knows that through the virtual clinic he can discuss his condition with the nurse and that at any time and from anywhere he can get individualised information and advice, and also peer support. The assisted living service ensures he has an adequate supply of medication at all times, that he is complying with the regimen and that there is no chance of accidental overdosing. The dispensing unit, the heart of the service, is discrete, well-designed and small enough to take on holiday.

Jo Smith is a mild asthmatic and carries her smart inhaler with her. She automatically gets reminders to the home hub and to her hand-held communicator about external factors (such as atmospheric conditions) that may exacerbate her asthma and advice on how to cope. Jo has also signed up for an anywhere / anytime service that allows her to meet other local asthmatics and provides general advice on managing her condition. She has access to a named care adviser and co-ordinator and could attend a clinic, either real or virtual, if she wanted to. The number of times she uses the inhaler is automatically monitored and she is contacted if it is above or below the norm. Knowing that help is always
available allows her to stay in employment and look after the others in the family. Because both Mr and Mrs Smith work, school holidays require extra planning and they rely partly on local information and advice services to find out-of-school services to ensure their Jane is looked after.

Jane Smith is overweight and is being bullied at school. She complains one morning of a sore throat. The parents take a swab of her throat and check her respiratory function through the home diagnostic centre. The results are automatically sent to the assisted living service. They log on using their biometric smart card and the service automatically interprets the readings, provides appropriate advice and suggests a course of action. If necessary an appointment with a care professional is made and a prescription issued to the pharmacy. Andy and Jo Smith can ask for more information either on-line or face-to-face.

Jane is keeping a blog about her bullying which she can complete anywhere and anytime through her hand-held communicator, and which allows her to share her experiences and thoughts with peers. As well as providing support, her class teacher has encouraged her to enrol in an on-line individualised behavioural change programme. This rewards her for keeping to the programme and for meeting milestones. The support through the combination of her blog and the change programme is ensuring that she gets the most out of her school years.

Key Messages from the vignette

- Technology does not replace face-to-face contact with carers and this must always be available as an option
- The emphasis is on prevention, self care and social inclusion
- Assisted living must be integrated with other services and parts of life from pre-work, through work to retirement
- The same basic services are required by each generation - only the detail of delivery changes
- Assisted living products and services should be designed for life and be non-stigmatising
- Assisted living services must be seamless to the user

Applications mentioned in the vignette

The home hub is a universal device that is the distribution point for all forms of communication to and from the house. It supports various communication protocols and interface devices including the removable hand-held communicator. Some sensors are permanently connected to the appropriate monitoring service through the hub. See: Home Hub and Sensors (H1)

The hand-held communicator is the workhorse of the system and everybody has one. In the vignette it is used to deliver health and social care information but it has many other uses. In the home the information that would have been on small screen of the communicator is automatically redirected to bigger fixed screens giving increased functionality. See: Home
Hub and Sensors (H1)

The *smart inhaler* is an example of a general range of *personalised applicators* that people use. They check that medications are being delivered as prescribed and measure relevant parameters. For instance the smart inhaler checks and records that it is being used correctly and measures the respiratory function simultaneously. The applicators hold similar information to the *biometric smart card* so that they can be uniquely identified. See: On-body monitoring (I19)

It is standard procedure to have an *implanted sensor* when undergoing transplant operations. These small biocompatible devices are powered from miniature cells and communicate with a receiver worn outside the body and then via the hand-held communicator to the monitoring service. The first ones were used in conjunction with valve and hip replacements. The next generation is self powered using blood or air flow to drive nano-dynamos. See: In-body monitoring (I18)

The *home diagnostic centre* is a peripheral device attached to the *home hub*. It can perform a range of diagnostic tests. The test data and other contextual information are sent to the monitoring centre. Once authenticated, the centre provides suggestions on appropriate next steps. It is linked to both automatic and managed decision support and triage services. See: Visiting Doctor’s Bag / Clinician PDA (H4)

The dispensing unit can be configured to support the medication usage that the patient favours from blister pack to refillable carousel. Its function is to record compliance with the regimen. It also has the facility to adjust the dose on instruction from the centre. See: Medication alerts (Including “intelligent pill dispensers”, “SMS alerts”, “intelligent medication”) (I2, I3, I4)
4.3 Scenario 2 – “Divergence”

The “divergence” scenario shows a situation where technological progress is high but the NHS does not make the best use of the applications available. There are pockets of innovation and change but national strategies are limited as the majority funding is consumed by the almost unsustainable wage bill. Much of the uptake and innovation of wireless ICTs in healthcare is driven by individuals, supplied by private firms and paid for outside the NHS.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic growth and funding</td>
<td>High</td>
</tr>
<tr>
<td>Technological progress</td>
<td>High</td>
</tr>
<tr>
<td>Structure of the NHS</td>
<td>Partially devolved</td>
</tr>
<tr>
<td>Use of information</td>
<td>Moderate</td>
</tr>
<tr>
<td>Personal engagement</td>
<td>Moderate</td>
</tr>
<tr>
<td>Level of morbidity</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

This scenario assumes that over the next 20 years economic growth will be high at a level of around 2.25% per annum and an increasing share of GDP will be invested in healthcare – 10.3% of GDP for health and long term care. This results in spending on health and long term care increasing by 108% to £215 billion by 2025. Technological progress within this scenario is high. Private companies have high profits which they re-invest into research and development resulting in an introduction of a number of breakthrough products to the market. However, it is private health companies and the wealthy individuals who are making the majority of purchases. There are significant developments within non-health related technologies and, as a result, the public are spending a larger proportion of their incomes on technology than ever before.

Pressures to invest in technology and to innovate are significant within health policy, but adoption has been much lower than expected given the economic and technological climate. This is attributed to a number of factors. The public are not confident about the security and safety of healthcare technology and the media are generally negative about the use of ICTs within healthcare following early implementation problems. Within the NHS, ICT use is patchy and there is no clinical evidence of efficiency gains. Staff are less motivated to make use of the new ICTs that have been employed, often reverting back to traditional methods.

Although funding levels are high within this scenario, income growth (directly related to economic growth) has led to huge labour costs within the NHS. The inconsistent adoption of ICTs has meant that increased efficiency has been patchy and there are few instances where labour has been substituted. Because rising labour costs have consumed higher proportions of government health expenditure, this has constrained funding for the capital costs of innovations and their implementation remains contained within a handful of more affluent regions.

The use of information within this scenario is moderate, largely due to the patchy implementation of ICTs within the healthcare system. Privacy concerns from the media and the public have prevented the government from collating and storing as much information about patients as they would have liked for
clinical research. There is an abundance of information available to patients, but it is not delivered in a coherent digestible manner and in many cases the provenance of information is not fully understood. Patients have, however, successfully formed more patient groups and informal peer-to-peer networks have become widespread utilising existing web applications such as forums and social networking sites. The health service is struggling to balance the time and cost of collating information against its usefulness and clinicians are often bombarded with huge quantities of unprocessed data. Information agents are not common within the health service – only being used in more affluent areas where they can afford the additional resources. Following the implementation of national IT programmes patient information has become accessible whatever the patient's location, enabling more immediate and accurate care.

Within this scenario personal engagement is moderate. Higher disposable incomes mean that people spend more on discretionary healthcare products but higher disposable incomes have also led to an increase in lifestyle related illnesses such as diabetes and liver failure. People see the effects of ill health but the inconsistent delivery of information means that they are less able to take responsibility for their own health. However, because of the rapid developments within healthcare technologies there are a number of generally more affluent people who spend a relatively large proportion of their growing disposable income on discretionary health purchases enabling them to monitor their own health. For this group, this helps to shift responsibility from the healthcare system towards the individual. However, while the government tries to engage the public in their healthcare, generally with limited resources they are unable to provide the necessary support for less affluent families.

Restructuring of the healthcare system within this scenario has happened in parts, but not universally. Whilst drivers such as the ageing population have forced some restructuring – for example primary care is increasingly delivered within the home – this has largely been ad-hoc. Hospital closures to make way for the polyclinics and super hospitals model are harder to drive through within this climate of high economic growth. Furthermore, successful restructuring of the NHS relies on a high adoption of ICTs to enable the easy transfer of data between locations, but the lower and unpredictable adoption of ICTs within this scenario has hampered the success of the restructuring programme. Health and social care continue to work as separate institutions, both using incompatible information systems preventing the easy sharing of information.

The level of morbidity in this scenario is also moderate. In some cases advances in diagnostics and screening have enabled more targeted intervention, leading to a reduction in illnesses reaching maturity before being diagnosed. However, the ageing population and increases in lifestyle related illnesses mean that there are still a high number of hospital admissions and people requiring long-term disease management. Morbidity is increasingly polarised with the more affluent people living longer healthier lives because of their discretionary health purchases, whereas the less affluent, information poor are increasingly suffering from long-term lifestyle related illnesses.

**4.3.1 Divergence Vignette**

**Orla and chronic disease diagnosis**

Whilst on holiday in France Orla begins to feel unwell – she is suffering from abdominal pain, being sick and had a fever. Orla checks the results from her mobile medical bracelet that is incorporated within her watch, by remotely logging into her home hub. Her results are all normal apart from a raised body temperature, usually at night. Orla self-medicates whilst in France taking anti-sickness tablets and aspirin to relive her temperature at night. When she returns from France she makes an appointment online at her local GP surgery. By filling in a few questions online she is prioritised and offered an emergency appointment first thing on Monday morning. With Orla’s permission the GP, Dr Tan, is able to log into her home hub from his computer, removing the need to carry out simple tests such as blood pressure. Dr Tan likes...
the home hubs as they save him considerable amount of time. However, not all of his patients can afford these home systems, and they are not provided by the NHS except for extreme cases. Having looked at Orla’s results he notes the rise in body temperature at night and also that in the last week Orla has lost a substantial amount of weight. Dr. Tan looks up Orla’s summary care record from the NHS “spine” to see if she had any past illnesses of significance. For Orla’s symptoms it is impossible to diagnose the problem outright – Dr Tan needs more information. He arranges for some tests to be carried out which would identify whether Orla is suffering from an infection. Until the test results are returned 48 hours later, there is nothing that the GP could prescribe and so he asks Orla to come back in for an appointment on Wednesday. The GP logs onto the surgery website and books an appointment for Orla.

Meanwhile, Orla feels just about well enough to return to work and on Tuesday she travels to Leeds to attend a business meeting. Unfortunately, during the business meeting Orla begins to feel very unwell, her symptoms have become dramatically more severe in the last few hours. Checking her mobile medical bracelet Orla can see that her temperature has increased quite dramatically. Orla is taken to Leeds general hospital accident and emergency. Leeds general hospital has recently been re-built and Orla notices how clean and new everything seems compared to her local hospital in London which was built 25 years ago. Orla is checked in and a RFID identification tag is put round her wrist. The nurse explains to her that the bracelet not only contains her basic information such as her date of birth and allergies but it would also track her whereabouts within the hospital.

Orla is taken to a treatment area where a doctor assesses her. The doctor is able to access her full medical records online, but unfortunately the test results are not yet been uploaded. The doctor decides to repeat the tests within the hospital, where the results will be ready in a few hours. Additionally, the nurse takes some blood samples at the bedside. Before doing so she scans Orla’s identification tag using her portable RFID scanner to double check that she is the correct patient. The nurse can check the blood sample immediately using a portable sample test machine. The results are displayed on the screen and automatically uploaded using the hospital WLAN network to the central system. Meanwhile the doctor who has returned to her office is alerted of the results. She is able to open the results on her PDA and submit the necessary course of treatment. Using her communicator Doctor Chan alerts the nurse that she has uploaded the course of treatment allowing the nurse to administer the correct treatment, in this case a potassium drip, in a matter of minutes.

Orla’s other test results come back the following morning and the possibility of an infection is ruled out. At this stage Dr Chan suspects that Orla may be suffering from Crohn’s disease. She checks the decision support system on her PDA and sees that, as she suspects, the next diagnostic test required is an endoscopy. Orla is taken to a treatment room where she swallows a large tablet which contains a camera within it. The camera wirelessly transmits pictures of her stomach over the hospital’s WLAN network to the central system.

Later that day Dr Chan is able to access the pictures from the wireless endoscopy on her laptop and unfortunately it confirms what she suspected – Crohn’s disease. Dr Chan logs on to Orla’s records online where the other test results have been uploaded. They all confirm her diagnosis. Orla is told of the diagnosis, and the specialist nurse spends some time with Orla answering her questions. She also gives Orla a large selection of information leaflets and a number of website addresses. Orla is prescribed some anti-inflammatory medication which aims to get the Crohn’s disease into remission. A follow up appointment is made at her local hospital, UCLH in two weeks time.

When Orla returns home she looks up Crohn’s disease on the internet. She is surprised by the vast numbers of websites and forums that are listed and isn’t sure where to start. After looking at a few of the websites Orla is beginning to feel overwhelmed and confused. Much of the information seems to be contradictory and she doesn’t understand why different people have been prescribed different drugs from her. Some of the stories that are posted make her feel very worried.

A week later Orla is sent an SMS reminder of her appointment. The SMS contains a link to a website which she can access from her mobile or on the internet if she needs to cancel the appointment. When Orla arrives for her appointment a week later she has a chance to ask the doctor lots of questions that had been bothering her since she looked up
Crohn’s on the internet. The doctor patiently explains everything to her. He understands how patients can get confused because they aren’t provided with clear, accurate information. Dr Evans has accessed Orla’s notes from the NHS “spine” and he is impressed with the level of detail that Leeds general hospital collated on her condition – it has made it much easier to assess what the correct course of treatment will be for Orla over the coming months and years. Dr Evans also practices privately and is accustomed to the level of information that is collected routinely on private patients from a number of sources including information submitted from patient’s home hubs. He realises that private providers have more resources to invest in collating and analysing the data turning it into useful information, but with the NHS still providing the majority of care within the UK Dr Evans would like to see the same level of information use across the whole of the health care system – he believes that the insights could save lives in the future.

**Key Messages from the vignette**

- In chronic disease management access to information about the patient before they present at a health service can provide invaluable insights and can speed up the diagnostic process
- Whilst advanced technologies can help in locally, national and possibly international consistency is vital for information to be useful in the long term
- Private providers may be in a position to encourage the use of technology within the NHS
- Technologies purchased privately could increase social divisions but could ultimately put pressure on the NHS service to provide them for those that can’t afford them
- Hospitals are unlikely to have the same ICT infrastructure – technology is developing rapidly whereas hospital systems are only renewed occasionally. Older hospitals may struggle to implement new technologies

**Applications mentioned in the vignette**

*Mobile medical bracelet* – this collects basic information about Orla such as her heart rate, blood pressure and temperature and transmits it to the *home hub*. See: [On body monitoring](#)

*Home hub* – the home hub collates information collected from the mobile medical bracelet. It collects data wirelessly when the patient is in fairly close proximity to the receiver. When the patient is away from home the data can be collected using public networks. See: [Home Hub and Sensors](#)

*RFID identification bracelets and tags* allow patients and staff to be located and tracked. See: [Radio-frequency identification (RFID) applications](#)

Clinicians within hospitals have automatic access to *electronic medical records* via the NHS “Spine” which are downloaded, formatted so that the essential information which may be required in an emergency is easily accessible. See: [NHS Care Records Service](#)

Nurses use the *portable RFID scanner* to scan patient’s identification tags which can automatically confirm that they are treating the correct patient. Potentially all medication bottles would also have RFID tags on them so that the nurse can check that they are dispensing the correct medication and dosage etc. See: [Radio-frequency identification (RFID)](#)
The portable sample test machine is used at the bedside to analyse samples automatically and transmit the results to the hospital central hub using the WLAN network. See: Vital sign monitoring at the bedside (M11)

A wireless endoscopy is a swallow-able device that passes through the digestive system takes pictures and transmits them wirelessly to a nearby receiver. See: Diagnostic body area networks (M12)

PDAs are used by clinicians to access their email, and patient information whilst they are on the move. Whilst the clinicians are within the hospital they access data using the hospital WLAN network, but outside of the hospital the clinician can access data using the GSM networks. See: Clinician PDAs (M9)

All the clinicians within Leeds general hospital are issued with a communicator which uses voice recognition technology to allow clinicians to communicate with each other directly without having to remember numbers or contact details. See: Mobile Communication Device for Clinicians (M5)

SMS reminders are automatically sent to patients before an appointment reminding them location date and time and allowing them to cancel it online if necessary. See: Appointment reminders via mobile phone (I1)
4.4 Scenario 3 – “The health service makes good”

In the “health service makes good” scenario we also see a largely positive scenario. However, in this scenario the NHS makes excellent use of available technology in order to compensate for the reduction in economic growth and funding. The rate of morbidity is still moderate due to unavoidable trends in demographics.

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<th>Driver</th>
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<tbody>
<tr>
<td>Economic growth and funding</td>
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<tr>
<td>Technological progress</td>
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<tr>
<td>Use of information</td>
<td>High</td>
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<tr>
<td>Personal engagement</td>
<td>High</td>
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<tr>
<td>Level of morbidity</td>
<td>Moderate</td>
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In this scenario, despite moderate economic growth of around 2%, the share of GDP spent on healthcare increases to 9.6%. Expenditure on health and long term care increases by 82% to £182 billion by 2025.

Modest economic growth means that private companies have less profit to re-invest into research and development resulting in less technological progress. However, health technology is a growing area with both the NHS and the general public spending greater sums of money on it than ever before. As a result technology companies are focusing their research and development on health innovations and have made some significant developments.

Despite a lower level of funding overall within the NHS, ICTs have been successfully deployed throughout the NHS. Technology and innovation are seen by the Department of Health as essential to the continued success of public health delivery. Health policy is focused on long term issues allowing investment into practices that may not demonstrate immediate benefits and would otherwise have been ignored. Funding within the NHS has been channelled towards technology and innovation development resulting in significant breakthroughs in all three types of health technology. There has also been a general substitution of labour with technology resulting in a more efficient NHS with lower labour costs. Programmes such as the National Programme for IT and N3 have been successfully deployed, largely due a shift in staff and patient attitudes towards ICTs in healthcare. Furthermore the evidence for long term gains from widespread implementation of health technologies and ICTs is available and the government has subsidised many technologies to encourage widespread uptake.

The effective sharing and exploitation of information has become one of the health service’s biggest assets. The development and increased use of ICTs within the health service enables all information to be captured, collated and analysed providing invaluable insights and further improving care. Patients are seen as consumers of information as well as producers and peer-to-peer networks have become commonplace. Whilst the Department of Health does not check all of the information within these sites, they are successfully self-governed by the users. As well as these informal networks the government has appreciated the benefit of knowledge sharing amongst patients and has implemented formal network and support...
structures empowering patients where desired. Where possible, healthcare has become standardised, allowing widespread use of decision support systems and systems such as the “Map of Medicine”. A number of initiatives including The National Knowledge Service have been a great success. As a result, information is readily shared with patients, and their original fears of security and safety are overcome as they see the huge benefits of widely accessible information. There are now information agents within all healthcare settings whose responsibilities include confirming the provenance and accuracy of data.

Within this scenario there is a significant shift of responsibility from the health services onto the individual. Access to health information is widespread and people are increasingly knowledgeable about their health. As lifestyle illnesses become commonplace and people see the effects first hand there is a general public movement towards taking responsibility for preventing future ill health. In particular, people use technology to monitor their health much more closely for early signs of common chronic diseases such as diabetes. For those already diagnosed with chronic diseases they are able to monitor their condition closely. Information that is collected about their condition is presented to them in a simple, comprehensible way allowing them to make informed decisions and manage their condition more effectively. Ultimately, this reduces the burden on GPs who are able to dedicate more time to urgent cases.

The health service has been restructured despite the lack of funding available. In this environment of sluggish economic growth, the public and NHS staff are resigned to the necessary hospital closures. Furthermore, the huge deployment of ICTs has allowed the restructuring to occur with minimal effort, as transfer of information is effortless between locations. Greater integration of health and social care mean patients experience unified delivery of care. As the government looks for ways of reducing costs private suppliers have become more commonplace within the NHS. Furthermore there has been an increase in the number of patients using private healthcare solutions as an alternative to the NHS.

Although in this scenario the NHS is performing exceptionally well in non ideal circumstances, residual lifestyle related illnesses and the ageing population continue to increase the burden on healthcare. The benefits of developments in GENTEC are yet to have had a substantial impact and while there have been developments in MEDTEC they are largely limited to improvements in medicating and delivering drug therapies. Nevertheless, developments in ICTs have improved disease management and the shift towards personal responsibility amongst the public has reduced many unavoidable illnesses.

4.4.1 Health service makes good vignette

Giles and emergency care

Giles Baker is driving his daughter Rachel and her two friends Jane and Sam back to University in Leeds, from their home in London. Half way up the M1 the front tyre of their small car bursts, and Giles loses control. The car spins and eventually comes to a stop, sideways on in the fast lane. Despite its collision warning system, a large white van cannot avoid slamming into the stationary car.

Rachel, sitting in the front passenger seat, has taken the least of the impact, and manages to force open the door, but realises that Sam and Jane are both trapped in the back seat. Giles is obviously in deep shock, and cannot open his door. The motorway traffic has come to a complete standstill but the emergency services are already on their way, having been alerted by Giles’ vehicle’s telematics system.

The police are the first to arrive, and as they do so send instructions to close the motorway to following traffic and set up...
diversions. Fire and ambulance services arrive shortly after.

The lead ambulance paramedic, John, rapidly assesses the situation. He notes that Rachel is sitting on the verge, being comforted by a number of passengers from following vehicles. The van driver has climbed out of his vehicle and is obviously shocked, but has no apparent injuries. John concentrates on the occupants of the car, and first asks everyone if they are OK, whether and where they have pain, and – to check for spinal injuries – whether they can move all four limbs.

John carries a small PDA, which immediately and automatically picks up wireless messages from the medical ‘bracelets’ incorporated in Giles’ and Jane’s watches, which identify them and give basic medical information about serious illnesses, allergies and prescriptions. Giles has the latest model, which measures his vital signs. Sam’s bracelet has been smashed and since he has taken the full force of the impact, John leans into the car and attaches a remote monitoring device to his arm.

John’s paramedic colleague, Richard, has already alerted the trauma centre at Leicester Royal Infirmary, and has given preliminary information about the accident, the number of casualties and the apparent injuries. The hospital staff send out a simultaneous alert to the accident and emergency team, surgical and anaesthetic staff, theatres, imaging, ITU and the blood bank, which is updated as further information from the accident site is received.

The information from the bracelets has automatically been transmitted to the control panel in the ambulance, and already the full electronic medical records of all four occupants of the car have been accessed and are available to Richard, formatted to give easy access to the information relevant to the emergency such as age, blood group and key illnesses.

Giles is still too shocked to speak but is breathing. John knows from the transmitted medical information that he is on a high dose of warfarin, and fearing internal bleeding his next priority is to get him out of the car and into one of the waiting ambulances. Once in the ambulance, Richard uses a hand-held ultrasound machine to check for internal bleeding, and discusses the results with the specialist at the hospital. On advice from the specialist, he checks that Giles has not recently suffered a stroke, and administers a drug to counteract the effect of the warfarin.

Sam and Jane are showing obvious signs of pain in the pelvic region, and John has given them oxygen, and attached an intravenous infusion line. The next priority is to get them out of the car. Richard has already taken a video of the car, showing the damage and the position of the occupants, because this will provide useful information about the probable extent of the injuries to the doctors waiting at the hospital. On John’s signal, four firemen move forward with cutting gear, and rapidly cut through the supporting struts to lift the roof off the car. John can now examine Sam and Jane more directly, and satisfied that there does not appear to be any obvious head or spinal injury, they are lifted out of the car and stretchered into the second ambulance.

Richard has already sent a message to the trauma centre, with the vital signs information from Giles’ bracelet and the remote monitoring devices, the quick access key to their medical records stored on the national database, and the video film of the car.

Although Rachel has no apparent injuries, she seems shocked, and John decides all four passengers should be taken to
Leicester, recognising the psychological importance of keeping them together. The van driver has only superficial injuries, but he too is taken to the hospital so that he can be fully examined to ensure there are no unseen complications.

Giles is sent off in the first ambulance, with Sam and Jane following in a second vehicle, once they have been freed, with Rachel and the van driver in the third. In the ambulances all five are monitored by fixed vital signs equipment, and the data sent forward to the hospital.

On arrival at the hospital, Giles is taken straight into a treatment bay in the trauma area. His personal identity is recorded again from his watch, and this is automatically uploaded to create a new record of his attendance at the hospital. He is given an RFID enabled wristband to track his location within the hospital.

Sam is examined and x-rayed in the trauma area, and a fractured pelvis and significant internal bleeding is confirmed. The staff check the hospital information screen to see which emergency theatre is available and ask the duty surgeon and anaesthetist to come down to the trauma area to assist with the assessment.

Giles’ assessment reveals a collapsed lung, and he is given a local anaesthetic and a tube is quickly inserted into his chest through a small surgical incision so that the lung can be re-inflated.

Meanwhile, Jane’s x-ray confirms a broken collarbone, and the possibility of a minor fracture to the pelvis. The radiographer conducts a search and summons up digital copies of previous x-rays from the Whittington Hospital in London, accessed via the national database. A close comparison using enhanced digital imaging confirms the suspicion that the minor pelvic fracture is new.

Sam is taken straight to ITU, where he is attached to the full range of remote monitoring devices.

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**Key Messages from the vignette**

- The first priority in a multiple injury accident is on-site triage – establishing an order of priority for intervention that reflects the apparent severity of injury, the latter being influenced by the nature of the accident, and whether for example, any of the casualties have been thrown from the vehicle.
- With technical support appropriate care can be provided at the accident site, and in the ambulance, which becomes a mobile treatment area as well as a command centre.
- Gathering information about patients’ medical history (eg Giles’ warfarin use) can be vital in informing the priority and type of clinical intervention.
- Sending advance information to the hospital can save valuable time when patients arrive in the accident unit and ensures that the relevant staff can be alerted.

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**Applications mentioned in the vignette**

John’s PDA connects wirelessly to the medical bracelets worn by the passengers, overriding normal access controls, to extract identity and summary medical information. The PDA automatically copies this information to the control desk in the ambulance. See: PDAs for paramedics (A3) and On body monitoring (I20)

The medical bracelets worn by the passengers contain identity and summary medical information, including allergies, medications and other facts that might influence a clinical decision. The bracelets can take the form of jewellery or be incorporated into a watch. Giles has a more advanced version that also monitors vital signs. See: On body monitoring (I20) or On-body / in-body mass triage sensors (A2)

The remote monitoring device attached to Sam’s arm measures vital signs. See: On body monitoring (I20)

Emergency ambulances are equipped with a control panel that acts as an information centre for on-board monitoring devices, and a communications link to medical record systems and destination hospitals. See: Ambulance hub (A4)

Ambulance staff have automatic access to full electronic medical records which are downloaded, formatted so that the essential information which may be required in an emergency is easily accessible. See: NHS Care Records Service (M17)

Hand held ultrasound is a portable hand-held machine. Ultrasonic waves and their echoes produce images of organs and systems inside the body. As technology has improved, smaller handheld devices that produce good quality images are being developed. Ambulance staff will have had specialist training in the use of the ultrasound. See: Ultra-stethoscope (M22)

Information forwarded to the hospital includes the quick access key to the patients’ full medical record, to save time in verifying identity. See: NHS Care Records Service (M17)

The fixed vital signs equipment in the ambulance allows for constant monitoring of a patient’s condition to indicate any change during the journey to the hospital. It is automatically connected to the patient’s record. See: Vital sign monitoring at the bedside (M11)

RFID bracelets and tags allow patients and staff to be located and tracked in the hospital. See: Radio-frequency identification (RFID) applications

Enhanced digital imaging simply allows digital x-rays taken at different times to be digitally compared to highlight changes. See: PACs (M8)
4.5 Scenario 4 – “Everything in moderation”

This scenario assumes that the NHS will make some moves towards utilising available technology, but that it will largely be hampered by the lower economic growth. Whilst there are areas that will see progress and innovation, it will be at a slower rate than envisaged.

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<tr>
<td>Level of morbidity</td>
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This scenario assumes that economic growth will be modest (around 2%) and health and long term care as a proportion of the NHS increases from 8.0% in 2005 to 9.6% in 2025. Spending on health and long term care will increase to £182 billion by 2025. Modest UK economic growth is associated with a modest pace of technology development. This scenario also assumes that there are no major technological breakthroughs such as the internet or mobile telephony in the next 20 years with developments limited to improving existing systems.

Technology and innovation are not given the highest priority within health policy and only limited funding is dedicated to it. As a result investment into technology and innovation within the NHS is modest, and whilst there are developments in ICTEC, GENTEC and MEDTEC there are no large scale investments seen previously in schemes such as the National Programme for IT. Politicians are nervous of making long term funding decisions as economic growth becomes less predictable. Use of technology within the NHS continues but at a relatively slow rate, and there are few breakthrough discoveries that make major differences to the delivery of care. The NHS has made use of technology to increase efficiency but because of the lack of consistency and interaction between different sectors these efficiency gains are yet to be seen. Staff are generally positive about the majority of technology that is implemented within the health system but a significant proportion feel that technology is being used to replace them and are largely negative, and in some cases, disruptive towards ICT or technology implementations.

The use of information within the NHS is patchy. There are localised instances of information being collected, collated and analysed but sharing of information on a national scale is limited. Whilst the national roll out of the fibre optic network has been completed there are a number of problems that have prevented it from being deployed successfully in all regions. Additionally, programmes to standardise care have not been deployed and as a result local practices still exist. The public increasingly rely on ICTs within all areas of their lives and as a result are more accepting of technology use within healthcare. ICTs are used to access health information, but with no formal systems or networks to encourage sharing of information amongst patients the information they access is often confusing and the provenance misunderstood. Additionally, there are still some concerns around reliability, security and privacy of health technologies which are slowing the rate of adoption within the NHS.
Personal engagement has become increasingly polarised. The more affluent information-rich segments of the population are accessing information and spending a larger proportion of their incomes on discretionary health purchases. On the other hand, there is still a rump of the population who continue to live generally unhealthy lifestyles and rely on the NHS to provide healthcare once they become ill. Personal engagement has increased where the NHS or social care has provided technology to monitor chronic diseases, but these systems are not widespread and in some regions people are forced to rely more on traditional approaches. The government encourages research into a number of topics such as obesity, preventative health measures and the role of personal engagement but the results are often contradictory making it difficult to send out a coherent message to the public.

The restructuring of the NHS has occurred to some degree, but its progress has been slower than anticipated. With a lack of national focus and long term policy from the government, restructuring has been patchy and inconsistent. The implementation of polyclinics varies by region and GPs have not been incentivised to change as there is a lack of evidence to support the claimed benefits. Additionally, the focus on carbon neutrality by the government has contradicted much of the vision for polyclinics and specialist hospitals, which would involve longer journeys. The relationship between health and social care improves but they continue to act as separate entities using different IT systems.

The level of morbidity within this scenario is moderate. A combination of increased personal engagement by some and developments in technology improving monitoring and care means that many chronic diseases are managed more efficiently allowing the NHS to focus on emergency care. Furthermore, despite limited funding into MEDTEC and GENTEC there are developments in both areas which help to reduce morbidity rates. Nevertheless, lifestyle related illnesses, an ageing population and inconsistent delivery of ICTs mean that morbidity within certain groups of people remains high.

**4.5.1 Everything in moderation vignette**

**Stephen and elective surgery**

Stephen Marshall is a retired teacher aged 79. He has lived alone since his wife died two years previously. Stephen was a keen cyclist until he developed problems with his right knee over the last few years, which has now become increasingly stiff and painful especially when going up and down stairs. Overall, his physical function has slowly begun to decline. Using small, portable imaging equipment, backed up by second opinion from the NHS expert information system, Stephen’s GP diagnoses possible osteoarthritis.

Osteoarthritis is a degenerative disease of the joints, associated with age and physical activity, as well as genetic and other factors. In 2020 it remains the most common reason for hip or knee replacement. With the ageing population, total demand for hip replacements has risen by a quarter and total knee replacements by over two-thirds since the late 1990s. While there were advances in the first decades of the 21st century in symptomatic relief using drugs and physiotherapy, no cure exists or is imminent. Ultimately, joint replacement is necessary. However, developments in surgical techniques, including the use new implant materials with in-built monitoring and intelligence, have significantly improved outcomes and reduced the length of stay in hospital.

Stephen’s osteoarthritis is initially treated with medication and physiotherapy, which initially alleviates the symptoms. The programme is managed carefully, with Stephen receiving reminders to take his medication via his phone, TV and PC as
appropriate. The majority of patients with musculoskeletal disorders are managed by trained local practitioners, with easily accessible health information through the web and backed up by support from appropriate specialists such as rheumatologists and pain management experts, through video links when necessary. Sharing expertise means that the range of treatment options available to patients is greater than in the early 21st century. Some patients need to go for additional assessment in the secondary care system, but in the majority of cases local practitioners are able to manage the condition.

While the medication and physiotherapy works initially, Stephen is eventually recommended for surgery to replace the knee and he is booked into his local hospital for an operation in five weeks’ time. The booking triggers the ‘single assessment process’ (SAP), a holistic evaluation of Stephen’s social and health care needs and his post-operative telecare requirements. This will provide him with an integrated package of care both within and out of the hospital. In many cases, including Stephen’s, this assessment is carried out online and a face-to-face consultation is only triggered if certain parameters are not met. Introduction of the SAP has proved to be harder than expected and in some health authorities there is still little or no integration between the health and social care record systems. In Stephen’s area, however, there has been full integration for several years, greatly reducing the duplication of record-keeping and improving the quality of care.

Over the last twenty years patient pathways have been streamlined. The organisation of elective and emergency surgery processes has been supported by information systems which are able to carefully balance the two patient flows, thus avoiding unnecessary cancellations and related delays to elective surgery. This has allowed patients to access appropriate care without the long waits associated with the old days of the NHS, partly because better information and advice means there are few inappropriate referrals – both new and follow-up – to secondary care. Consultant surgeons ‘freed up’ time is therefore translated into extra elective operating sessions.

Once Stephen’s operation has been scheduled he is provided with an intelligent gait monitoring system. This includes a wearable device and a package of sensors in his home, and is designed to provide a baseline assessment of his gait prior to the operation. This allows his knew ‘smart knee’, which will provide feedback on wear and tear through use, to be calibrated. Data from the gait monitoring system is sent directly to the manufacturer of the new knee.

Rapid and accurate diagnosis, support in the community, better scheduling of elective surgery, and organisational changes across the care system boundaries have therefore combined to greatly improve the pre-operation experience for patients such as Stephen. A far more personalised operating and treatment plan has been devised for him than was the case in the early 21st century.

On the day of this operation, Stephen arrives at his local community hospital. In the 1990s the NHS began to open treatment centres that only carried out elective hip and knee operations. Some of these were privately run, but as the efficiency of the NHS improved during the early 21st century, demand fell away and they have all been subsumed into the local foundation trusts. A significant proportion of elective general surgery procedures are now carried out in community hospitals, mainly as short-stay and day cases. Many minor and intermediate procedures requiring local anaesthesia are carried out in polyclinics, community health centres or GP practices.

Stephen’s pre-operation assessment is carried out and he is given a patient tracking tag, for audit and safety purposes.
Health Technology Scenarios

He is also given an estimated discharge time, which automatically triggers a provisional reservation for transport home and alerts the primary care and social services to activate his post-operative care package. Later that evening he is taken down to the operating theatre. The operation itself is, in this case, carried out by a small surgical team, although robotic surgery, monitored by experts off-site, is the norm in more remote locations.

The decreased trauma associated with developments in surgery, supported by advances in imaging, has continued to reduce the time patients spend in hospital and extend the range of eligible patients. Some advances involve new techniques to treat highly complex and previously inoperable problems, but many are new ways of approaching existing procedures, such as knee replacement. These combine the use of minimal invasion for precision surgery and bio-artificial organs or smart prosthetics.

After the operation, Stephen spends the night in hospital, where his initial recovery is locally monitored via bedside sensors. The aim is to send patients home as quickly as possible to minimise time in a hospital bed – hospital acquired infections still remain a problem, albeit much less so than twenty years previously. The next morning he is discharged and his recovery and rehabilitation package, based on the SAP evaluation, begins.

When he arrives home a nurse from his local polyclinic checks that his immediate needs are addressed and later that day a temporary telecare and telerehabilitation system is installed. This allows his local community telecare service to monitor the recovery period, including his activities of daily living and the use and effectiveness of the prosthesis. When combined with his rehabilitation programme – some of which is provided virtually via digital TV – healthcare professionals are able to focus on his individual needs as they evolve. Stephen is also provided with far more information as part of his self-care package, reducing the need for follow-up appointments. Because of the involvement of a multi-disciplinary team which includes specialists in old age medicine and rehabilitation when following up patients, complications following elective surgery – once common for frailer older people – have been greatly reduced.

Monitoring the performance data from his new knee during its use in a ‘real-life’ context – the home, going to the shops and so on – provides the manufacturer with valuable feedback for future innovation and the local health authority with performance data for surgical audit.

Stephen’s new knee proves a great success and, aged 82, he is able to resume his hobby – cycling.

**Key Messages from the vignette**

- Technology does not replace face-to-face contact with carers – Stephen receives support from his GP, physiotherapists, pain control experts, and orthopaedic specialists. However, face-to-face contact is backed up by expert information systems to provide a high standard of personalised care.

- Feedback on the progress of Stephen’s medication and physiotherapy regimen allows it to be carefully adjusted to his changing needs.

- There is a high level of integration between acute, primary and social care services both before and after his
operation, with data sharing to allow more accurate decision making.

- Careful tracking of patients within the hospital, together with rapid discharge, improves the quality and safety of care.

<table>
<thead>
<tr>
<th>Applications mentioned in the vignette</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video conferencing allows Stephen, his GP and others involved in his care to communicate when needed. See: <a href="#">Video conferencing for healthcare (H2)</a></td>
</tr>
<tr>
<td>Home hub and sensors, and a body area network, allow pre- and post-operative monitoring of Stephen. See: <a href="#">Home Hub and Sensors (H1)</a></td>
</tr>
<tr>
<td>Interactive computerised therapy, including through use of video link via the digital interactive TV, helps manage Stephen’s condition after diagnosis and provides post-operative rehabilitation support. See: <a href="#">Interactive Computerised Therapy (H3)</a></td>
</tr>
<tr>
<td>RFID tracks Stephen in the hospital. See: <a href="#">Radio-frequency identification (RFID) applications</a></td>
</tr>
<tr>
<td>Stephen’s medication is provided via an electronic prescription service, which also provides medication reminders. See: <a href="#">Medication alerts (Including “intelligent pill dispensers”, “SMS alerts”, “intelligent medication”) (I2, I3, I4) and: Electronic prescription services (I8)</a></td>
</tr>
<tr>
<td>There is a fully integrated care record, embracing social, primary and acute care. See: <a href="#">NHS Care Records Service (M17)</a></td>
</tr>
</tbody>
</table>
4.6 Scenario 5 – “Stagnation”

“Stagnation” is the most negative scenario. A combination of low economic growth and technological progress lead us to a situation where the NHS is unable to deliver care at the level the public expects. There are also fears around privacy and security of information preventing major structural change and adoption of ICTs.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic growth and funding</td>
<td>Low</td>
</tr>
<tr>
<td>Technological progress</td>
<td>Low</td>
</tr>
<tr>
<td>Structure of the NHS</td>
<td>Partially devolved</td>
</tr>
<tr>
<td>Use of information</td>
<td>Low</td>
</tr>
<tr>
<td>Personal engagement</td>
<td>Low</td>
</tr>
<tr>
<td>Level of morbidity</td>
<td>Low</td>
</tr>
</tbody>
</table>

This scenario assumes that economic growth is low at around average 1.75% per year. Public funding for health and long term care increases to 9.2 of GDP%. Health and long term care spending increases to £164b by 2025. Growth in public spending on health is constrained by slow economic growth and other spending pressures from education, pensions and defence. Debts within the NHS (from the private finance initiative) consume an increasing proportion of health spending. Additionally, whilst the wage bill is relatively lower within the NHS because of low income growth, the requirement to fund staff pensions requires significant additional funding. The global health economy is also slowing.

Within this scenario, the current momentum of technology progress tails off. Technology companies have lower profits and therefore make smaller investments into research and development, reducing the number of new, innovative products that are introduced to the market. Technology and innovation are no longer at the forefront of NHS policy as the government focuses policy on addressing immediate problems within the NHS. Harsh regulation and public privacy fears prevent innovation within ICTEC and developments within GENTEC and MEDTEC are hampered due to lack of funding. Although there are some minor developments in drug therapy there are no new breakthrough drugs or major genetic advances.

Lack of funding and unforeseen problems have prevented unified deployment of systems such as the National Programme for IT. The national roll out of fibre optic is seen as unnecessary and alternatives such as WiMAX are adopted in some areas to compensate. Some rural areas suffer and are not connected to ICT systems further alienating them from care. A lack of direction from the Department of Health over national standardised initiatives means that local practices remain in place, preventing widespread use of decision support systems. Patient information that is collected remains as data on local networks because of the lack of integration between systems and widespread privacy fears. Information use amongst patients is also limited as the NHS is unable to provide them with clear concise information through a standard delivery method. Past changes and innovations within the healthcare system which were unsuccessful have created a culture of mistrust and a risk aversion. Peer-to-peer networks were set up at the beginning of the 20 year time frame, but they were misused and therefore unsupported by the health service.
By and large, the public are not taking responsibility for their health. People have relatively lower incomes and spend less on discretionary healthcare. Inadequate availability of technologies to help people manage chronic diseases themselves means that they are forced to rely more heavily on the primary care system. Additionally, monitoring technologies have not been fully developed and therefore focus primarily on more reactive – rather than preventative – care. Although the effects of poor health become widespread and people see them first hand, information availability and incentives to improve their health are limited. People are not willing to make personal sacrifices for the “greater good” and believe that the NHS should provide them with the care they need regardless of the cause of their illness. Whilst the government can see the problems that lifestyle related illnesses are causing for healthcare they lack the necessary funding to spend on long term preventative measures and focus on the short term problems they face.

The structure of the NHS by and large remains unchanged. There are some changes early on within the 20 years but the vision of decentralised services is undermined by lack of supporting evidence for the efficiency gains. Additionally, lower growth within the economy means that there are no funds available for the transitional costs that are inevitable in such large scale change. NHS policy is driven by short term goals as the government is hesitant to make long term funding commitments given the uncertain economic climate. Integration between health and social care services is restricted and each continues to act as entirely separate entities causing a confusing situation for older patients where the responsibility of care is often unclear.

The ageing population places a huge burden on the NHS as the number of age-related chronic diseases rapidly increases. Families further fragment, reducing the contribution from family carers which in 2007 was estimated to be saving the health and social service some £87 billion per year\(^8\). Social care is only able to provide for very poor individuals and people rely on the health service to care for them as their conditions deteriorate. Furthermore, lifestyle related illnesses increase dramatically as preventative initiatives are not implemented in time. Monitoring and screening technologies are not widely deployed, resulting in less prevention or intervention at an early stage of illness. This further increases morbidity and eventually mortality rates. Diseases and viruses that had previously been eradicated within the UK begin to re-emerge as immigration and foreign travel increase. Increasingly the NHS is unable to cope as demand for healthcare rapidly increases and, as a result, they are only able to provide reactionary short term healthcare.

### 4.6.1 Stagnation Vignette

**Tariq and Tina and maternity care**

Tariq and Tina Saddiqi found out a month ago that Tina is pregnant with their first child, and they are delighted. So is Tariq’s mother, Rina, who’s been sharing their flat since she stopped being able to live on her own, three years ago. Tina trained as a book-keeper but has been unable to find work, so has been caring for Rina, who is getting increasingly frail and forgetful. Luckily Tariq makes a decent living as a self-employed plumber.

For the first few weeks of her pregnancy, Tina has sought information about morning-sickness from parenting magazines and has also looked online. There is a lot of information and advice out there on the internet, but a lot of it is from America and Australia, and most of the UK information is heavily commercial (“brought to you by….”), and so it’s hard to know what to trust.

\(^8\) Carers save the UK £87 billion per year, Carers UK, [link](#)
The couple go together to inform their GP. They phone for an appointment but are told they will have to come in and wait. Tariq recalls that the last time he went to the GP a few years ago, with a wrist sprain, the surgery was trialling online booking but evidently that never got adopted. The GP completes and signs a form which will be couriered to the local hospital to get them registered. This district general hospital has a poor reputation for clinical outcomes and hygiene, and they ask if they can be given an alternative hospital for the birth. The GP says no, but tells them that in spite of all the bad press around at the moment, childbirth is the thing that the NHS does excellently, and reassures Tina that she and the baby will be well looked after.

At 20 weeks the Saddiqis go for an ultrasound check-up. The radiographer is a highly qualified locum from Russia and his English is poor. But they are happy to hear that the baby is developing fine, and seems to be a girl. Afterwards they ask for a photo of the foetus for them to take away and show to friends. But they learn that the hospital has stopped allowing these photos because of data-protection and privacy concerns – the unborn baby cannot give consent for the photo, which would thus infringe its right to privacy under new (and in Tariq's view, ridiculous) legislation.

Their patient record is updated by the hospital following the scan, and given to Tina in a glossy folder full of inserts and advertisements from baby-equipment companies and attractive private maternity hospitals. It is explained to them that this is the only record of the scan that exists, so they should keep it very safely. Tariq and Tina feel it is risky not to have a backup of this data, and are advised to make a photocopy, or to use one of the online "data-vaults" (offered by Google, Microsoft, Sina etc) which hold personal data securely.

As the due-date approaches, Tina's contractions begin and she calls the hospital midwives frequently to discuss the right time for her to be admitted to the hospital. She is not sure how dilated she is, and offers to send photos of herself from her handheld computer to the hospital. The midwives give her an email address to send the photos to, but it turns out not to work. In any case, the midwives prefer to discuss the symptoms over the phone (as their training and customary practice have taught them) and they do so with great expertise.

Eventually, Tina and Tariq are asked to come in. They grab their ready-packed luggage and drive to the hospital. At the hospital car-park, Tariq is annoyed to find that he cannot use his smart-phone to authenticate his car for parking, and has to use cash instead. "The first time I've had to use cash in a car park for years… what is it with bloody backward hospitals?" he mutters. They walk carefully up the stairs (lifts are out of order) to the delivery suite. Tina's waters have broken and the presence of meconium in the water means that she is rushed straight to the ward. However, in the rush of leaving the house, the couple have forgotten to bring their records with them. Tariq is told to go back home to fetch them immediately. He offers to call them up on his phone from his Google account, and even knows how to print to the nearest printer from his device (he uses that feature a lot as a plumber for quotes and bills), but the hospital staff are adamant that they require to see the paper copy with the clinicians' original signatures.

Tariq dashes off and returns with the records 40 minutes later. He's told that unfortunately he has just missed the birth of his daughter. His disappointment abates as he holds the newborn baby (although he subsequently regrets it and resents the hospital's insistence on paperwork). The ward is crowded and looks a bit grubby; the décor is shabby Victorian. But the clinical staff are nonetheless motivated and expert.

Tariq and Tina plan to call her "Noula Harriet Saddiqi" until Rina points out that her initials would be N.H.S. so they think again about the middle-name. But at least she's healthy… no, she's perfect!
### Key Messages from the vignette

- Patients often search for health information online. Although there is information available from the NHS and other healthcare bodies on the internet, patients may come across information provided from other sources in different contexts, such as forums. This information can be valuable, but may also be confusing for patients and is not a replacement for professional medical advice.

- There is a clear discrepancy between patients’ use of technology in their daily routine; patients’ expectations of technology applications - and the use of technology within the NHS.

- The interface and communication between the patient and primary care provider greatly affects the patient’s experience of the healthcare service.

- Within the health service, there is a fragmentation of the use and uptake of technologies which can affect healthcare delivery.

- Fragmentation of technology roll out and concerns over privacy have resulted in neither the NHS nor the patient having control of their personal health records. This causes inefficiency within the health service and confusion and inconvenience to the patient.

### Applications mentioned in the vignette

Tina seeks information about morning sickness from the internet. See Digital health info including peer to peer networks.
4.7 Differences in vignettes under each scenario

The previous section describes each scenario in general terms using a vignette to illustrate how the scenario would play out in the real world. Each vignette shows a different stage of healthcare delivery, from at-home care to emergency critical care within the hospital. This section highlights the differences between each stage of healthcare under the five different scenarios.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Vignette</th>
<th>Impact on vignette</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of Abundance - broadband is ubiquitous, very low cost and access is universal. Data from multiple sources is available securely.</td>
<td>At home care</td>
<td>See: <em>Age of Abundance Vignette: “The Smith family and at-home care”</em></td>
</tr>
<tr>
<td>Chronic disease</td>
<td>Hospitals are using the same IT systems throughout the UK and technologies such as RFID tagging are used everywhere leading to one harmonised system. Orla’s notes are available whichever hospital she is in and the level of care and information that she receives is the same regardless of whether she is in her “home” location or not. Patients have access to a wealth of information both nationally and internationally and all information has been moderated and is generally very accurate. She is also provided with equipment that allows her to monitor and record her condition on a day to day basis – eventually providing her with a highly personalised disease profile.</td>
<td></td>
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<tr>
<td>Emergency care</td>
<td>There are only minor differences between the ‘Age of Abundance’ and the ‘Health service makes good’ scenarios (e.g. the availability of intelligent medication), and none of these affects the vignette. The key elements in the vignette relate to the availability of personal information and access to records, and communications between the ambulance and the specialist team waiting in the hospital.</td>
<td></td>
</tr>
<tr>
<td>Elective surgery</td>
<td>There is full integration, both technically and organisationally, of data records between social, primary and acute care services. The single assessment process has been universally introduced, allowing a holistic evaluation of Stephen’s needs.</td>
<td></td>
</tr>
<tr>
<td>Maternity</td>
<td>Information is regulated and therefore more accurate, reliable and not biased. Online booking is possible at every stage of the pregnancy and Tariq and Tina are referred to the polyclinic to give birth, although they are also given the option of at-home birth or giving birth in the main hospital. Not only can Tariq and Tina take a copy of the scan but they are able to log on from home and view a saved 3D image of their baby in their personal online records. The huge collation of data has enabled the doctors to assess that Tina is more likely to suffer with high blood pressure and she is allocated a blood pressure monitor watch to wear nearer the end of her pregnancy alerting her GP in major changes to her blood pressure.</td>
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<tr>
<td>Scenario</td>
<td>Vignette</td>
<td>Impact on vignette</td>
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<td>--------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Divergence - broadband is ubiquitous, very low cost and access is universal. Data fusion is unreliable and there are unresolved technical issues with security.</td>
<td>At home care</td>
<td>Whilst the products and services described in the vignette are available uptake is patchy because of public concerns over security of information. Consequently the improvements in prevention and lifestyle change are not being realised so the demand for service is not reducing as predicted. There are a number of products and services available commercially</td>
</tr>
<tr>
<td></td>
<td>Chronic disease</td>
<td>See: Divergence Vignette: “Orla and chronic disease diagnosis”</td>
</tr>
<tr>
<td></td>
<td>Emergency care</td>
<td>The medical bracelets described in the vignette have been introduced, but they tend to be worn only by those with specific medical issues; the versions that combine with watches and jewellery have tended to be bulky and not popular with the public. The paramedic would use a remote monitoring device instead. Confidentiality concerns have resulted in many people opting out of universal access to their electronic records – although recent reports of deaths arising from the lack of critical information in emergency situations are persuading many of those to opt back in. Both Sam and Jane have, however, agreed that their records can be accessed with their or their next of kin’s specific consent, which they are able to give. Ambulance staff in the vignette have not received ‘FAST’ training, so although they have a hand-held ultrasound device they are unable to use it.</td>
</tr>
<tr>
<td></td>
<td>Elective surgery</td>
<td>The products and services are all available, but there is poor integration, both technically and organisationally. The single assessment process has not been introduced, so there is no holistic evaluation of Stephen’s needs. Data on Stephen’s post operative condition is available but not automatically distributed to all those involved in his care.</td>
</tr>
<tr>
<td></td>
<td>Maternity</td>
<td>Tariq and Tina are surprised to hear that they are not offered the same options as their friends Paul and Betty – they are told that their “area” is unable to offer the same services because of lack of integration between IT systems. However, all of their records are available online and their physician is able to access them at any point. Tina regularly measures her vital signs such as blood pressure using her at home kit and the doctor advises that she should print out her results to take with her to an appointment as they may not be able to access her personal hub from all hospitals.</td>
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## Health Technology Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Vignette</th>
<th>Impact on vignette</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health service makes good - NHS and social services has ubiquitous broadband and access to information but this is not available to the population at large</td>
<td>At home care</td>
<td>The interactive care services described in the vignette are available from a booth in the GPs surgery. Some local information and support services above the minimum level of personal safety and environmental security are available in the home over fixed and mobile telephone and digital television services provided by both private and public/private sector companies.</td>
</tr>
<tr>
<td>Chronic disease</td>
<td>Orla doesn’t have a medical bracelet which means that her diagnosis takes slightly longer, but once she is diagnosed with a chronic condition she is offered one free of charge on the NHS. After the initial diagnosis Orla is given up to date and highly relevant information which has been collated by the NHS. Doctors treating Orla have access to a wealth of national information which helps them chose the appropriate treatment path.</td>
<td></td>
</tr>
<tr>
<td>Emergency care</td>
<td>See: Health service makes good - &quot;Giles and emergency care&quot;</td>
<td></td>
</tr>
<tr>
<td>Elective surgery</td>
<td>The products and services are available, but only to those deemed to be in most need. In Stephen’s case, he is above the threshold which qualifies him for the full package of pre- and post-operative telecare services, and he purchases these from a local care monitoring and response provider.</td>
<td></td>
</tr>
<tr>
<td>Maternity</td>
<td>Tariq and Tine are impressed by the level of organisation within the NHS. They are provided with excellent information and they generally feel comfortable about the forthcoming pregnancy. Tina is offered the choice of where to give birth and she elects to use the specialist maternity hospital which has an excellent record for natal care. When she is admitted she is impressed to learn that her medical bracelet is RFID and therefore keeps track of where she is in the hospital, making her feel much safer. With the use of NHS provided telecare solutions Rina is able to continue living in her own home.</td>
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</table>
### Health Technology Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Vignette</th>
<th>Impact on vignette</th>
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</thead>
<tbody>
<tr>
<td><strong>At home care</strong></td>
<td></td>
<td>A minimum level of personal safety and environmental security is provided through ICT however certain patient groups receive home support services above this minimum through local initiatives which are supported by local voluntary organisations and sporadic central funding. The size of this market created is very small and there are a few private sector companies partnering with NHS and social services to provide the type of services described in the vignette.</td>
</tr>
<tr>
<td><strong>Chronic disease</strong></td>
<td>Hospitals are more reliant on wired communication infrastructures and Doctors are not able to access details on their PDAs. Orla doesn’t have a medical bracelet – the NHS only supplies these for patients with chronic conditions. Some private companies offer remote monitoring services but have failed to reach high levels of penetration because of high costs. Patient records are available electronically but they are limited to summary care records and are often slow to update – in the Leeds hospital they are unable to access the data that the GP has uploaded.</td>
<td></td>
</tr>
<tr>
<td><strong>Emergency care</strong></td>
<td>As with the ‘Health service makes good’ scenario, uptake of the ‘medical bracelets’ is patchy, and there are similar confidentiality concerns about universal access to medical records, though in this case ambulance and emergency clinical staff have authority to over-ride access controls to the central records database in defined emergency situations, and subject to completion of a ‘justification report’ that later has to be sent to the patient. Remote monitoring devices are not widely available; the initial specification required automatic connection to patient records, which has proved difficult because of confidentiality and access control issues. Although prototypes have been developed, funding has not been available to complete the project. Lack of funding for training ambulance staff has precluded the use of the hand-held ultrasound.</td>
<td></td>
</tr>
<tr>
<td><strong>Elective surgery</strong></td>
<td>See: <a href="#">Everything in moderation - “Stephen and elective care”</a></td>
<td></td>
</tr>
<tr>
<td><strong>Maternity</strong></td>
<td>Tina and Tariq are pleased that they are offered the choice of where to have the baby. However, their GP is nervous about letting them choose an at-home birth and they opt for the local hospital instead. Tina is surprised while she is in the hospital that electronic records don’t seem to have improved efficiency a great deal – nurses often print them out for doctors to read. Generally speaking Tina and Tariq rely on the internet for much of their information gathering about pregnancy and childbirth as the information they receive from the health service often feels slightly confused and contradictory.</td>
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<tr>
<td>Scenario</td>
<td>Vignette</td>
<td>Impact on vignette</td>
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</tr>
<tr>
<td>Stagnation - resolution of the technical</td>
<td>At home care</td>
<td>The products and services described in the vignette are not available and health and care services find difficulty in providing basic services.</td>
</tr>
<tr>
<td>issues surrounding security remain because</td>
<td>Chronic disease</td>
<td>Orla has to wait a week for her initial appointment with the GP as NHS services are massively over-subscribed and her condition is not seen as an “emergency”. By the time Orla reaches hospital her condition has deteriorated and therefore she spends longer as an in-patient. There is limited use of ICTs within the hospital and information continues to be provided inconsistently. Information provided by patients is limited to unregulated peer to peer networks.</td>
</tr>
<tr>
<td>there is no public or private sector</td>
<td>diagnosis</td>
<td></td>
</tr>
<tr>
<td>investment</td>
<td>Emergency care</td>
<td>Many of the technologies available in other scenarios are not present in this scenario, as a result of funding pressures, lack of investment in technology, and security concerns about the use and sharing of information. Ambulances attend promptly because this is a major accident, but they are not so well equipped, and less well connected to base. They are unable to access centrally held medical records, and have no direct video link to the destination hospital. In the hospital RFID tags are not used for patients. The accident and emergency department is much busier, because attempts to deal with minor injuries and ailments by localised walk-in clinics have failed to redirect patients, who still believe that the hospital is the best place to go, despite the long waits. Although as emergencies the car crash victims would receive priority treatment, they might have to wait longer to see a doctor or to access diagnostic services such as x-ray and ultrasound, compared to the other scenarios.</td>
</tr>
<tr>
<td></td>
<td>Elective surgery</td>
<td>Only a rudimentary post-operative telecare service is available, more advance than the systems that emerged in the early 2000s, but limited to ‘crisis and emergency’ events such as falls. This is provided by local social care as a stand-alone service – there is no integration of data with his healthcare record.</td>
</tr>
<tr>
<td></td>
<td>Maternity</td>
<td>See: Stagnation - &quot;Tariq and Tina and maternity care&quot;</td>
</tr>
</tbody>
</table>
4.8 Shocks

4.8.1 Impact of shocks on forces and scenarios

This section introduces the shocks and the impact that they will have on the scenarios. We return to the shocks in section 7 to discuss the impact that they may have on application use within scenarios and the resulting implications for spectrum.

There are three potential effects that a shock may have:

1. The direction of travel towards one scenario is altered and a different scenario becomes more probable
2. The position of the scenarios on the axis will change
3. Use of a particular application may suddenly increase or decrease

This section describes the effect that the shock will have on the super-forces and how this will alter the position of the scenarios shown on the axis. This section will not cover whether a particular scenario will become more or less likely to occur as section 7 covers all the different scenarios and the implications for spectrum. Additionally, section 7 describes where the use of a particular application suddenly increases or decreases.

4.8.2 Shock 1 - Influenza pandemic

A flu pandemic is an epidemic (sudden outbreak) of non-seasonal influenza that becomes very widespread affecting a whole region, country or even the world. In the UK there were three flu pandemics in the last century, and historically records indicate that influenza pandemics have occurred with an average frequency of over two per century since 1590.

Impact of flu pandemic on the health service

In the short term an influenza pandemic would dramatically increase demand on the health service. A European Commission study assumed impacts of +15% on the health service within the year of the pandemic. Because of the nature of funding it is highly unlikely that the health service will be able to increase supply in such a short space of time to meet that demand. Furthermore, health professionals would be at higher risk of catching the infection and if vaccination was ineffective the number of health professionals affected would be disproportionately large compared to the population as a whole.

Impact of flu pandemic on the scenarios

Overall the level of economic growth and therefore technological progress will fall. Over 20 years an influenza pandemic may reduce average growth by around 0.4% per annum. Although technological progress will fall, the level of communication technology usage may increase temporarily as people seek ways to communicate without travelling. Furthermore, historically, in times where the economy or health has been put under large pressure, such as during war, there tends to be more appetite for innovative solutions often resulting in major technological breakthroughs. The impact on the structure of the health system is very much dependent on the level of restructuring that has already occurred in each scenario; with scenarios

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9 Medicinenet.com, 2008
10 Indepen, 2007
11 Indepen, 2007
12 Indepen, 2007
13 Indepen, 2007
having progressed further along with the restructuring progress more likely to continue. An influenza pandemic will increase morbidity rates dramatically during the year of the pandemic – it is likely that 25% of the population will be affected by an influenza pandemic\textsuperscript{14} with around a 5% mortality rate\textsuperscript{15} but over a 20 year timeframe it is unlikely to have a vastly significant impact.

4.8.3 Shock 2 - Labour shortage / income level shock

A labour shortage within the health service simply refers to a lack of skilled individuals able to work within the health service. This could be caused by a movement of health workers to another country or too few people undertaking the necessary medical training. An income level shock refers to income level rises that are significantly greater than inflation. This could be caused because of a labour shortage or could be the result of wider economic forces.

Impact of a labour shortage / income level increase on the health service

The healthcare industry is a very labour intensive industry. Therefore, a labour shortage or an income level increase could have a large negative effect on the health service as a whole. There are some solutions to the problem, for example, importing workers from other countries but there are costs associated with such strategies. The most notable effect on the health service from a public perspective will be the level of care that people receive:

1. Fewer hospitals remain open
2. “Non-essential” services are cut so that more funding can be allocated to fund the wage bill
3. Clinical staff are forced to work longer hours

\textsuperscript{14} Department of Health
\textsuperscript{15} Indepen, 2007
Impact of a labour shortage on the super forces

A labour shortage or increase in income level will place further pressure on funding. There are two opposing outcomes; firstly, available funds are directed away from other priorities - such as technology implementation, or secondly, technology solutions are used to improve efficiency and reduce the burden on staff. Use of information within the health service will be de-prioritised as the short term funding pressures will outweigh the potential long term benefits of collating and analysing information. The level of restructuring will accelerate to some degree as centralised hospitals provide a more efficient structure for staffing, although this will be dependent on the level of funding available after the wage bill has been met. Overall, levels of morbidity will increase; fewer available medical staff will undoubtedly lead to a reduction in the level of care.

4.8.4 Shock 3 – Major data security breach

This shock describes a situation where the public suddenly lose confidence in the government’s ability to hold their personal data. This could have been caused by a security breach or a significant loss of data due to human or technological errors. Alternatively, the system holding data becomes significantly less reliable, preventing clinicians from accessing the necessary information when required.

Impact of a major data security breach on the health service

Clinicians lose confidence in unreliable systems and revert back to paper records. The public place extra pressure on the government to invest into the ICT infrastructure and in the meantime perceive it to be safer to keep their own records.

Impact of a major data security breach on the scenarios

This shock will cause use of information within the health service to be severely hampered. It is highly unlikely that the public will be comfortable about the health service collecting, storing and analysing data about their health. The general public will continue to share information although we would expect that...
people may be more careful about sharing personal information. The restructuring of the health care system is somewhat reliant on the introduction of basic ICT systems such as NHS Spine and N3 and this shock will slow the rate of progress.

4.8.5 Shock 4 – Major technological breakthroughs – e.g. miniaturisation, battery life

Impact of sudden breakthrough on the health service
We have captured the majority of applications which will be used in the next 20 years in section 5. However, there will inevitably be breakthroughs that will alter the technology landscape and its development. An example breakthrough may be a sudden improvement in battery life which will affect a number of different technologies. Increasingly we are seeing trends in miniaturisation which make applications more suitable for a hospital environment – but a sudden development or breakthrough will lead to a number of changes occurring in a short space of time. For the purpose of this example we assume that there has been a sudden breakthrough in battery life.

Impact of a technology breakthrough on the scenarios
This shock could dramatically increase the level of uptake of technology both within the health service and more generally. Increased battery life would remove many of the barriers preventing applications such as in-body monitoring from being deployed. Technology development will also be stimulated; developers are able to concentrate on building portable applications without the usual reduction in battery life. As a result, the use of information will increase as devices to measure and record data become portable and can be worn for long periods of time. This will lead to an increase in personal engagement as people are able to monitor their health accurately and with minimum disruption.
4.8.6 Shock 5 – Major disaster e.g. bomb, nuclear accident

Impact of a major disaster on the health service

In the long term a localised bomb would have no impact on the health service. A continued threat of terrorism may alter health policy in terms of emergency planning and additional funding may be required to do this but over a 20 year time period the impact will be minimal. However, in the very near-term a bomb in a localised area would have a significant impact on the local health services – unexpectedly suddenly increasing demand.

Impact of a major disaster on the scenarios

The impact of a terrorist attack on the economy will depend on the severity and frequency of attacks as well as the government and public response. A one-off terrorist attack will not alter long term economic growth, although funding may be directed towards disaster planning or in more extreme cases to defence. A continued threat of terrorist attacks or a series of widespread attacks will have more impact on the long term economy, as secondary industries such as tourism are adversely affected. Technological progress may slow as a result of reduced GDP. However, depending on disaster plans put in place, communication technologies are likely to be of great importance during a disaster recovery.
Health Technology Scenarios

High economic growth and funding
High technological progress

Non restructured health service
Low personal engagement
Low use of information

Highly restructured health service
High personal engagement
High use of information

High economic growth and funding
Low technological progress

Stagnation

High levels of morbidity
Moderate levels of morbidity
Low levels of morbidity
5 Health ICT applications

5.1 Introduction
This section provides descriptions of the ICT applications that may be used in healthcare within the next 10-20 years. All applications could potentially use wireless technologies. Some of them would use wireless from 'end to end' whilst others might use wireless to connect to or from a wired network. In section 6 of this report, we map these applications against each of our five scenarios. All 50 of the applications listed in this section occur in our most positive scenario, “Age of Abundance”, through to only 18 out of the 50 in our most negative scenario, “Stagnation”.

Generally, we are confident that we have identified the main applications that will be the major users of wireless spectrum within the next 10-20 years. Inevitably there will unforeseen developments within the health and / or technology markets that may lead to the development of applications that we have not included within this section. However, the shocks section of this document has captured some of the application developments that are less predictable.

In some cases these applications in our list already exist but may be named something different and so, where possible, we have used generic names for the applications to remain consistent throughout the document. In section 4 of this report the vignettes may refer to the applications using a slightly different name to bring them to life but they all relate to applications within this section. Links are provided in the application section of the vignettes.

5.2 Methodology
We have used a number of methods to establish this list of health technology applications that may be used within the next 10-20 years:

- Brainstorming within external workshops
- Literature survey
- Interviews with technology companies
- Interviews with key stakeholders within the UK health service
- Brainstorming within project team

We have organised these applications according to location:

- Individual / Anywhere (i.e. applications related to the individual, wherever they are)
- Ambulance
- Home
- Hospital or GP surgery

For a more detailed description of each application see annex D.

5.3 Individual / Anywhere
These are applications that could be used anywhere. This includes in the settings elaborated below (home, hospital, ambulance) as well as “out of home”.

These are listed below.

<table>
<thead>
<tr>
<th>#</th>
<th>Application</th>
<th>Type of application</th>
<th>Description</th>
<th>Exists / imminent</th>
<th>Decision required from gov’t or NHS</th>
<th>Tech advancement required</th>
<th>Commercial investment required</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Appointment reminders via mobile phone</td>
<td>Admin</td>
<td>Automatic reminders sent to a patient’s mobile phone via SMS</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>12</td>
<td>Medication alerts - intelligent pill dispensers</td>
<td>Admin</td>
<td>Pill bottles that send an alert if they haven’t been opened</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>13</td>
<td>Medication alerts – SMS</td>
<td>Admin</td>
<td>An automatic SMS is sent to the patient’s phone to remind them to take medication</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>14</td>
<td>Medication alerts - intelligent medication</td>
<td>Admin</td>
<td>Sensors on the medication itself that recognise if they have been administered</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>15</td>
<td>SMS Pharmacy location</td>
<td>Admin</td>
<td>Patient can access details of their closest pharmacy using SMS</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>16</td>
<td>SMS pharmacy drug location</td>
<td>Admin</td>
<td>The patient can access details of the closest pharmacy with their medication available</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>17</td>
<td>SMS payment for prescription charges</td>
<td>Admin</td>
<td>The patient can pay for a prescription charge using</td>
<td>x</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Scenario</td>
<td>Department</td>
<td>Description</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>I8</td>
<td>Electronic prescription services</td>
<td>Admin</td>
<td>Prescriptions are sent electronically to prescribers</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>I9</td>
<td>Mobile interpretation services</td>
<td>Admin</td>
<td>Language or deaf interpretation services provided on mobile devices</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>I10</td>
<td>Nutritional content scanning</td>
<td>Discretionary</td>
<td>Scan food items to access nutritional information</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>I11</td>
<td>Remote personal trainer</td>
<td>Discretionary</td>
<td>Vital signs etc sent to a remote personal trainer</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>I12</td>
<td>MMS photos to NHS direct or similar</td>
<td>Diagnostic</td>
<td>Send MMS photos of ailments to NHS Direct for diagnosis</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>I13</td>
<td>Infectious disease sensors</td>
<td>Diagnostic</td>
<td>Sensors in busy public places measuring signs of infectious diseases</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>I14</td>
<td>Alarms / falls monitors (from patient to hub)</td>
<td>Communications</td>
<td>An alarm which wirelessly transmits a signal if the wearer falls</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>I15</td>
<td>Alarms / falls monitors (from hub to call centre)</td>
<td>Communications</td>
<td>The comms link between the alarm / hub and the call centre</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>I16</td>
<td>Digital health info including peer to peer networks</td>
<td>Communications</td>
<td>Health information stored digitally. Most likely to be accessed by</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>patients using the internet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>-----------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>I 17</td>
<td>In-body monitoring</td>
<td>Body Area Networks</td>
<td>Devices which can monitor bodily functions internally. For example it may measure the levels of insulin within the patient’s blood stream.</td>
<td>☒</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>I 18</td>
<td>In-body drug delivery</td>
<td>Body Area Networks</td>
<td>Drugs which are delivered through a device within the body. For example a device which delivers the correct dose of insulin to a diabetic patient.</td>
<td>☒</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>I 19</td>
<td>On-body monitoring</td>
<td>Body Area Networks</td>
<td>Devices which monitor pulse, blood pressure or other functions from outside the body.</td>
<td>✓</td>
<td>☒</td>
<td>☒</td>
<td></td>
</tr>
<tr>
<td>I 20</td>
<td>Interface between BAN and hub</td>
<td>Body Area Networks</td>
<td>Comms link between the body area network and the hub that stores the information.</td>
<td>✓</td>
<td>☒</td>
<td>☒</td>
<td></td>
</tr>
</tbody>
</table>
5.4 Applications in the ambulance

<table>
<thead>
<tr>
<th>#</th>
<th>Application</th>
<th>Type of application</th>
<th>Description</th>
<th>Exists / imminent</th>
<th>Decision required from gov’t or NHS</th>
<th>Tech advancement required</th>
<th>Commercial investment required</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1</td>
<td>Video conferencing</td>
<td>Ambulance</td>
<td>Devices which are portable and enable paramedics to conference with specialists in the hospital / other location</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A 2</td>
<td>On-body / in-body mass triage sensors</td>
<td>Ambulance</td>
<td>Devices which monitor patient’s vital signs and include basic medical information.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
</tbody>
</table>
## Health Technology Scenarios

<table>
<thead>
<tr>
<th>Size of potential addressable market</th>
<th>Video conferencing (A1)</th>
<th>PDAs for paramedics (A3)</th>
<th>On body / in body mass triage sensors (A2)</th>
<th>Ambulance hub (A4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universal</td>
<td>60 million</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significant</td>
<td>30-60 million</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>1-30 million</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Niche</td>
<td>&lt;1 million</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Paramedics can access these details wirelessly.

**A 3**

**PDAs for paramedics**

Portable devices for paramedics which are specially designed to enable easy communication and access to key data.

| ✔ | ✔ | ✗ | ✗ |

**A 4**

**Ambulance hub**

A hub which accesses patient’s records, sends information to and from the hospital and records patient’s vital signs.

| ✔ | ✔ | ✗ | ✗ |

**Approximate time application will reach maximum addressable market**

- **2008** Already exists / imminent
- **+10 to 20 years**
5.5 Applications in the home

These are applications that necessarily take place in the patient’s home. All the applications listed under “individual-level anywhere applications” in the section above could also take place in the home.

<table>
<thead>
<tr>
<th>#</th>
<th>Application</th>
<th>Type of application</th>
<th>Description</th>
<th>Exists / imminent</th>
<th>Decision required from gov’t or NHS</th>
<th>Tech advancement required</th>
<th>Commercial investment required</th>
</tr>
</thead>
<tbody>
<tr>
<td>H 1</td>
<td>Home Hub and Sensors</td>
<td>In-home</td>
<td>The home hub collects and stores information from the sensors. Sensors measure the daily activity of the resident.</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>H 2</td>
<td>Video conferencing</td>
<td>In-home</td>
<td>Web cams used by residents to communicate over video with their friends and family (or perhaps health practitioner).</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>H 3</td>
<td>Interactive Computerized Therapy</td>
<td>In-home</td>
<td>Computer packages that provide cognitive behavioural therapy.</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>H 4</td>
<td>Visiting doctor's bag / PDA</td>
<td>In-home</td>
<td>A portable device which allows the health practitioner to access the health records of the patient from the NHS spine as well as their home hub, if relevant.</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>
5.6 Applications within the hospital or GP surgery setting

All the applications listed under “individual-level anywhere applications” in the section above could also take place in the clinical setting.

<table>
<thead>
<tr>
<th>#</th>
<th>Application</th>
<th>Type of application</th>
<th>Description</th>
<th>Exists / imminent</th>
<th>Decision required from government or NHS</th>
<th>Tech advancement required</th>
<th>Commercial investment required</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 1</td>
<td>RFID to track assets</td>
<td>RFID</td>
<td>RFID tags enable moveable assets to be tracked using a simple interface</td>
<td>✔</td>
<td>✔</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>M 2</td>
<td>RFID to track patients</td>
<td>RFID</td>
<td>Wrist bands would include RFID tags enabling the location of patients within the hospital</td>
<td>✔</td>
<td>✔</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>
### Health Technology Scenarios

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M 3</strong></td>
<td>RFID to track staff</td>
<td>RFID</td>
<td>Staff within the hospital could enable their RFID tags so that they can be located within the hospital</td>
<td>✓</td>
</tr>
<tr>
<td><strong>M 4</strong></td>
<td>RFID and pharmaceuticals</td>
<td>RFID</td>
<td>Pharmaceuticals can be tagged and therefore tracked if stolen, for example</td>
<td>✓</td>
</tr>
<tr>
<td><strong>M 5</strong></td>
<td>Mobile communication device</td>
<td>Communications</td>
<td>A device which enables staff to instantly talk to each other using voice recognition technology</td>
<td>✓</td>
</tr>
<tr>
<td><strong>M 6</strong></td>
<td>Remote presence robots</td>
<td>Clinical</td>
<td>Robotics which enable doctors to carry out procedures on a patient remotely</td>
<td>✓</td>
</tr>
<tr>
<td><strong>M 7</strong></td>
<td>Diagnostic tests at the bedside</td>
<td>Clinical</td>
<td>Tests such as blood or urine tests are carried out at the bedside and the results are automatically uploaded to the patient’s record</td>
<td>✓</td>
</tr>
<tr>
<td><strong>M 8</strong></td>
<td>PACS</td>
<td>Clinical</td>
<td>PACS enables images such as x-rays and scans to be stored electronically and viewed electronically on screens</td>
<td>✓</td>
</tr>
<tr>
<td><strong>M 9</strong></td>
<td>Clinician PDAs</td>
<td>Clinical</td>
<td>A portable device enabling clinicians to access email, patient records, video conferencing etc.</td>
<td>✓</td>
</tr>
<tr>
<td><strong>M 10</strong></td>
<td>Research Database</td>
<td>Clinical</td>
<td>A database which anonymously aggregates data from</td>
<td>✓</td>
</tr>
</tbody>
</table>
## Health Technology Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Clinical</th>
<th>Body Area Networks</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M 22</strong></td>
<td>Ultra stethoscope</td>
<td></td>
<td></td>
<td>✓ ✓ ✗ ✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M 11</strong></td>
<td>Vital sign monitoring at the bedside</td>
<td></td>
<td></td>
<td>✗ ✓ ✗ ✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M 12</strong></td>
<td>Diagnostic body area networks</td>
<td></td>
<td></td>
<td>✗ ✓ ✓ ✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M 13</strong></td>
<td>Re-programming of in-body sensors</td>
<td></td>
<td></td>
<td>✗ ✓ ✓ ✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M 14</strong></td>
<td>Room clean sensors</td>
<td></td>
<td></td>
<td>✗ ✓ ✓ ✗</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Patients on a national, long term scale**:
  - A potable handheld ultrasound which would ultimately replace the stethoscope. Images would be electronic and would enable results to be automatically uploaded to the patient’s record.
  - Sensors that would transmit vital signs wirelessly to a computer or PDA. Any important changes in the vital signs would sound an alarm.
  - Sensors which are small enough to be swallowed which can then perform diagnostic functions from temperature and biochemical measurements to endoscopy. Data is wirelessly sent to sensors on the body or close to the body.
  - In-body sensors could be wirelessly recalibrated to adjust to changes in the patients’ physiology / morbidity.
  - Sensors which alert hospital staff if a room hasn’t been cleaned within a certain timeframe.
## Health Technology Scenarios

| M 15 | Smart cards | Admin | A card containing a chip which holds personal, contractual and health clearance information about clinicians. Could also be used to regulate entry into certain areas within a hospital. | ✓ | ✓ | ✗ | ✗ |
| M 16 | Electronic Prescription Services | Admin | Prescribers are able to send prescriptions electronically to a dispenser of the patient’s choice. | ✓ | ✓ | ✗ | ✗ |
| M 17 | NHS care records | Admin | One electronic central repository of health care records, including a summary care record | ✓ | ✓ | ✗ | ✗ |
| M 21 | Equipment status monitoring | Admin | Equipment is monitored remotely, so if a piece of equipment stops working the correct member of staff is notified. | ✗ | ✓ | ✗ | ✓ |
| M 18 | Patient video displays | Patient Apps | Patients have a screen which they can access a webcam from their home. | ✓ | ✓ | ✗ | ✗ |
| M 19 | Internet connectivity for patients | Patient Apps | Patients and visitors are able to access a public wireless network within the hospital. | ✓ | ✓ | ✗ | ✗ |
| M 20 | Mobile interpretation services | Patient Apps | The device automatically translates using voice recognition technology. | ✗ | ✓ | ✓ | ✗ |
## Health Technology Scenarios

<table>
<thead>
<tr>
<th>Size of potential addressable market</th>
<th>Access to research database (M10)</th>
<th>NHS care records (M17)</th>
<th>Vital signs monitoring at the bedside (M11)</th>
<th>Re-programming of in-body sensors (M13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universal</td>
<td>60 million</td>
<td>RFID to track assets (M1)</td>
<td>RFID to track staff (M3)</td>
<td>RFID to track patients (M2)</td>
</tr>
<tr>
<td>Significant</td>
<td>30-60 million</td>
<td>Electronic prescription services (M16)</td>
<td>Ultra stethoscope (M22)</td>
<td>Internet connectivity for patients (M19)</td>
</tr>
<tr>
<td>Moderate</td>
<td>1-30 million</td>
<td>RFID and pharmaceutical use (M4)</td>
<td>Diagnostic body area networks (M12)</td>
<td>Mobile communication device (M5)</td>
</tr>
<tr>
<td>Niche</td>
<td>&lt;1 million</td>
<td>Smart cards (M15)</td>
<td>Equipment status monitoring (M21)</td>
<td>PACS (M8)</td>
</tr>
<tr>
<td>2008</td>
<td>Already exists / imminent</td>
<td>Mobile interpretation services (M20)</td>
<td>Diagnostic tests at the bedside (M7)</td>
<td>Clinician PDAs (M9)</td>
</tr>
<tr>
<td></td>
<td>+10 to 20 years</td>
<td>Room clean sensors (M14)</td>
<td>Remote presence robots (M6)</td>
<td></td>
</tr>
</tbody>
</table>

Approximate time application will reach maximum addressable market
6 Characteristics and Usage of ICT Applications

6.1 Introduction
This section continues to work within the framework of the four locations identified in Section 5:

- Individual / Anywhere
- Ambulance
- At Home
- GP / Hospital

For each of these locations we look in more detail at the characteristics of the applications relevant to that location, in terms of the various factors that have a bearing on spectrum and network requirements (first table under each location); and then at the likely usage of each application within each scenario (second table under each location).

This information forms the basis for section 7, which sets out the implications for spectrum.

Where applications are used in more than one of the four locations identified above they have been repeated in order to provide a complete picture at each location (with the exception of an individual located at home where it might be expected that most if not all of the individual / anywhere applications would also occur).

As discussed in section 5 all applications have the potential to use wireless technologies for all or part of their journey across networks. When identifying the relevance of wireless technologies to each application a number of aspects have been considered, including:

- The need for mobility
- The user’s expectation of convenience
- The availability of public and private third-party networks (both wired and wireless)
- The greater appropriateness of wired connections in critical static situations

6.1.1 Characteristics Tables
These describe the applications and their characteristics that are relevant to assessing the type of network required to support such an application. The characteristics considered are:

- Communication direction
- Communication type
- Distance
- Coverage type
- Traffic type
- Quality of service
- Frequency of data transfer
- Spectrum type
Need for mobility

“Spectrum type” is categorised as follows:

- **Licence exempt** – Application is likely to use wireless technologies but will either use licence exempt spectrum or spectrum provided by GSM carriers etc.
- **Allocated** – Application may require allocated spectrum
- **Wired** – Application is more likely to use wired technologies such as broadband

Initial consideration of the applications in the characteristic tables is related to the abundance scenario as in general this scenario is likely to give rise to the most extensive use of technology. It has been assumed that privacy / security issues are not a barrier to the introduction of technology.

### 6.1.2 Usage Tables

To determine the impact of health technologies on spectrum requirements, it has been necessary to evaluate and qualify the usage of each application under the five different scenarios. We have done this in two stages. First we ask: how large is this application, whichever the scenario? We label this its “maximum addressable market”. Second, we assess how much usage this scenario might expect in each of the five scenarios.

The maximum addressable market for each application is calculated based on the maximum current or maximum potential use of the application. For example, in calculating the addressable market for SMS appointment reminders it was assumed that every individual in the population would have a healthcare appointment at some stage in their lifetime - therefore this application would have a universal addressable market.

The classifications of the maximum addressable market are as follows, in terms of number of users, uses or deployments of each application:

- **Universal**: potential use to the whole population
- **Significant**: between 30 and 60 million
- **Moderate**: between 1 and 30 million
- **Niche**: Less than 1 million

The potential usage of each application under each scenario was then assessed, based on this maximum addressable market analysis. For each application, within each scenario, we have considered two aspects relating to usage. The first aspect is whether the application would actually exist and secondly whether the application would be wired or use wireless technology under each scenario. As a result, each application has two classifications which can be seen in the table below; usage is classified as high, medium, low or n/a (does not exist) and the nature of connectivity is classified as wired or wireless.

### 6.1.3 Illustrative diagrams

Finally, we have illustrated the different networks and their usage for each location.
6.2 Individual / Anywhere Applications

6.2.1 Individual / Anywhere Applications - Characteristics

The applications potentially relating to an individual are listed in the table below. The important characteristic that applies here is that an individual could be located anywhere (i.e. away from hospital or GP’s surgery and away from home).

<table>
<thead>
<tr>
<th>Individual/Anywhere Application name</th>
<th>Ref</th>
<th>Communications</th>
<th>Distance</th>
<th>Coverage type</th>
<th>Traffic type</th>
<th>Quality of service</th>
<th>Frequency of data transfer</th>
<th>Spectrum</th>
<th>Need for mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appointment reminders via mobile phone</td>
<td>1 1</td>
<td>One way</td>
<td>One to one</td>
<td>Regional (&lt;100km)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>Occasional</td>
<td>License exempt</td>
</tr>
<tr>
<td>Medication alerts – intelligent pill dispensers</td>
<td>2 2</td>
<td>One way</td>
<td>One to one</td>
<td>Regional (&lt;100km)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>Occasional</td>
<td>License exempt</td>
</tr>
<tr>
<td>Medication alerts - SMS</td>
<td>3 3</td>
<td>One way</td>
<td>One to one</td>
<td>Regional (&lt;100km)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>Occasional</td>
<td>License exempt</td>
</tr>
<tr>
<td>Medication alerts – intelligent medication</td>
<td>4 4</td>
<td>One way</td>
<td>One to one</td>
<td>Regional (&lt;100km)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>Occasional</td>
<td>License exempt</td>
</tr>
<tr>
<td>SMS pharmacy location</td>
<td>5 5</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional (100km)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>Occasional</td>
<td>License exempt</td>
</tr>
<tr>
<td>SMS drug location</td>
<td>6 6</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional (100km)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>Occasional</td>
<td>License exempt</td>
</tr>
<tr>
<td>SMS payment for prescription charges</td>
<td>7 7</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional (100km)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>Occasional</td>
<td>License exempt</td>
</tr>
<tr>
<td>Electronic prescription services</td>
<td>8 8</td>
<td>One way</td>
<td>One to one</td>
<td>PAN (&lt;10m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Moderate but not critical</td>
<td>When needed</td>
<td>License exempt</td>
</tr>
</tbody>
</table>
## Health Technology Scenarios

<table>
<thead>
<tr>
<th>Individual/Anywhere Application name</th>
<th>Ref</th>
<th>Communications</th>
<th>Distance</th>
<th>Coverage type</th>
<th>Traffic type</th>
<th>Quality of service</th>
<th>Frequency of data transfer</th>
<th>Spectrum</th>
<th>Need for mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile interpretation services</td>
<td>I 9</td>
<td>Both ways</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Voice</td>
<td>Moderate but not critical</td>
<td>Continuous</td>
<td>License exempt</td>
</tr>
<tr>
<td>Nutritional content scanning</td>
<td>I 10</td>
<td>One way</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, urban and rural</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>When needed</td>
<td>License exempt</td>
</tr>
<tr>
<td>Remote personal trainer</td>
<td>I 11</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>Occasional</td>
<td>License exempt</td>
</tr>
<tr>
<td>MMS photos to NHS direct or NHS choices or similar</td>
<td>I 12</td>
<td>One way</td>
<td>One to one</td>
<td>Regional (&lt;100km)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Images</td>
<td>Moderate but not critical</td>
<td>Occasional</td>
<td>License exempt</td>
</tr>
<tr>
<td>Infectious disease sensors</td>
<td>I 13</td>
<td>One way</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Moderate but not critical</td>
<td>Frequent</td>
<td>License exempt</td>
</tr>
<tr>
<td>Alarms / falls monitors (from patient to hub)</td>
<td>I 14</td>
<td>Both ways</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, urban and rural</td>
<td>Voice</td>
<td>Immediate and critical</td>
<td>Occasional</td>
<td>Allocated</td>
</tr>
<tr>
<td>Alarms / falls monitors (from hub to call centre)</td>
<td>I 15</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional (&lt;100km)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Voice</td>
<td>Immediate and critical</td>
<td>Occasional</td>
<td>Wired</td>
</tr>
<tr>
<td>Digital health information including peer to peer networks</td>
<td>I 16</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional (&lt;150km)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Video</td>
<td>Store and forward best efforts</td>
<td>Occasional</td>
<td>Wired</td>
</tr>
<tr>
<td>In-body monitoring</td>
<td>I 17</td>
<td>One way</td>
<td>One to one</td>
<td>BAN (&lt;10m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Immediate and critical</td>
<td>Very frequent</td>
<td>Allocated</td>
</tr>
<tr>
<td>In-body drug delivery</td>
<td>I 18</td>
<td>One way</td>
<td>One to one</td>
<td>BAN (&lt;10m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Immediate and critical</td>
<td>Very frequent</td>
<td>Allocated</td>
</tr>
</tbody>
</table>
### 6.2.2 Individual / Anywhere Applications – Usage

The usage and connectivity of the applications relating to the individual are listed below.
<table>
<thead>
<tr>
<th>#</th>
<th>Individual/Anywhere Application Name</th>
<th>Maximum addressable market</th>
<th>Age of Abundance</th>
<th>Health service makes good</th>
<th>Divergence</th>
<th>Everything in moderation</th>
<th>Stagnation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I 5</td>
<td>SMS Pharmacy location</td>
<td>Universal</td>
<td>Low Wireless</td>
<td>Low Wireless</td>
<td>Medium</td>
<td>Medium Wireless</td>
<td>High</td>
</tr>
<tr>
<td>I 6</td>
<td>SMS pharmacy drug location</td>
<td>Significant</td>
<td>Medium Wireless</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>I 7</td>
<td>SMS payment for prescription charges</td>
<td>Significant</td>
<td>Low Wireless</td>
<td>Low Wireless</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>I 8</td>
<td>Electronic prescription services</td>
<td>Niche</td>
<td>High Wired</td>
<td>High Wired</td>
<td>High</td>
<td>Medium Wireless</td>
<td>Medium</td>
</tr>
<tr>
<td>I 9</td>
<td>Mobile interpretation services</td>
<td>Universal</td>
<td>High Wireless</td>
<td>Low Wireless</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>I 10</td>
<td>Nutritional content scanning</td>
<td>Universal</td>
<td>High Wireless</td>
<td>Medium Wireless</td>
<td>Low</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>I 11</td>
<td>Remote personal trainer</td>
<td>Universal</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Low</td>
<td>Low Wired</td>
<td>n/a</td>
</tr>
<tr>
<td>I 12</td>
<td>MMS photos to NHS direct or similar</td>
<td>Universal</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Medium</td>
<td>Medium Wireless</td>
<td>Medium</td>
</tr>
<tr>
<td>I 13</td>
<td>Infectious disease sensors</td>
<td>Niche</td>
<td>High Wireless</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>I 14</td>
<td>Alarms / falls monitors (from patient to hub)</td>
<td>Moderate</td>
<td>High Wireless</td>
<td>Medium Wireless</td>
<td>Medium</td>
<td>Low Wireless</td>
<td>Low</td>
</tr>
</tbody>
</table>
# Health Technology Scenarios

## 6.2.3 Individual / Anywhere Applications – Analysis

It is clear from the above applications that there are four types of communication that need to be addressed:

- **The wide area exchange of non-critical information e.g. appointment reminders.** This would be likely to be supported by public wireless networks such as cellular, WiFi, WiMAX and beyond.
- **The body area exchange of critical information e.g. in-body drug delivery.** This would be likely to be supported by a wireless body area network using specific and appropriate frequencies.

<table>
<thead>
<tr>
<th>#</th>
<th>Individual/Anywhere Application Name</th>
<th>Maximum addressable market</th>
<th>Age of Abundance</th>
<th>Health service makes good</th>
<th>Divergence</th>
<th>Everything in moderation</th>
<th>Stagnation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I 15</td>
<td>Alarms / falls monitors (from hub to call centre)</td>
<td>Moderate</td>
<td>High Wired</td>
<td>High Wired</td>
<td>Medium Wired</td>
<td>Medium Wired</td>
<td>Low Wired</td>
</tr>
<tr>
<td>I 16</td>
<td>Digital health info including peer to peer networks</td>
<td>Universal</td>
<td>High Wired</td>
<td>High Wired</td>
<td>High Wired</td>
<td>Medium Wired</td>
<td>Low Wired</td>
</tr>
<tr>
<td>I 17</td>
<td>In-body monitoring</td>
<td>Niche</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Medium Wireless</td>
<td>Low Wireless</td>
<td>n/a</td>
</tr>
<tr>
<td>I 18</td>
<td>In-body drug delivery</td>
<td>Moderate</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Medium Wireless</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>I 19</td>
<td>On-body monitoring</td>
<td>Universal</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Medium Wireless</td>
<td>Medium Wireless</td>
<td>Low Wireless</td>
</tr>
<tr>
<td>I 20</td>
<td>Interface between BAN and hub</td>
<td>Moderate</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Medium Wireless</td>
<td>Medium Wireless</td>
<td>Low Wireless</td>
</tr>
</tbody>
</table>
The wide area exchange of critical information e.g. alarm to monitoring centre. This will likely need an interface between the body area network and public wireless networks. Given the potentially critical nature of such information exchange it is appropriate that alternative access to public wireless networks be provided.

The availability of a patient’s record.

A number of architectures could support the above requirement with different degrees of integration between the various ICT systems involved. However it is possible to envisage an architecture based on a body area network and a personal hub or gateway which provides a BAN / WAN interface and could potentially contain processing power and electronic storage relating to the control and monitoring of in-body and out-of-body medical devices. Such a personal gateway could also hold a patient’s record although other technologies (e.g. RFID) are possible for basic medical records in a hospital environment. As noted above the BAN to WAN interface should support a number of connection types (cellular, WLAN, Bluetooth, UWB and frequencies specific to healthcare e.g. social alarms).
6.3 Ambulance Applications

6.3.1 Ambulance Applications - Characteristics
The applications relating to the attendance of an ambulance and/or paramedic at an accident are listed in the table below.

<table>
<thead>
<tr>
<th>Ambulance Application name</th>
<th>Ref</th>
<th>Communications Direction</th>
<th>Type</th>
<th>Distance</th>
<th>Coverage type</th>
<th>Traffic type</th>
<th>Quality of service</th>
<th>Frequency of data transfer</th>
<th>Spectrum</th>
<th>Need for mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video conferencing</td>
<td>A 1</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional (&lt;100km)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Video</td>
<td>Moderate but not critical</td>
<td>Occasional</td>
<td>Allocated</td>
<td>On the move</td>
</tr>
<tr>
<td>On-body / in-body mass triage sensors</td>
<td>A 2</td>
<td>One way</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Immediate and critical</td>
<td>Quite frequent</td>
<td>Allocated</td>
<td>On the move</td>
</tr>
<tr>
<td>PDAs paramedics</td>
<td>A 3</td>
<td>Both ways</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data / voice</td>
<td>Moderate but not critical</td>
<td>Quite frequent</td>
<td>Licence exempt</td>
<td>On the move</td>
</tr>
<tr>
<td>Ambulance Hub</td>
<td>A 4</td>
<td>Both ways</td>
<td>One to many</td>
<td>Regional &lt;100km</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Images / Video</td>
<td>Immediate and critical</td>
<td>Quite frequency</td>
<td>Licence exempt</td>
<td>On the move</td>
</tr>
</tbody>
</table>

6.3.2 Ambulance Applications – Usage
The usage and connectivity of the of the applications relating to ambulances are listed below.

<table>
<thead>
<tr>
<th>#</th>
<th>Ambulance Application Name</th>
<th>Maximum addressable market</th>
<th>Age of Abundance</th>
<th>Health service makes good</th>
<th>Divergence</th>
<th>Everything in moderation</th>
<th>Stagnation</th>
</tr>
</thead>
</table>


### Ambulance Applications – Analysis

There are three communication aspects to this situation:

- The gathering of data from on-body / in-body mass triage sensors. Such a network of sensors may be pre-wired or it may be wireless.
- The interfacing of data from the above along with videoconferencing, PDAs and other wireless equipment to a distant location (e.g. hospital).
- The interfacing of a patient’s record and / or existing Body Area Network (through its personal hub / gateway) to equipment associated with the ambulance or onwards to a distant location (e.g. hospital).

A possible architecture to support the above requirements would be based on an ambulance having its own wireless Local Area Network which interfaces through its hub/gateway to the national network which supports public safety services (i.e. Airwave).

The three aspects identified above would connect to the ambulance WLAN and in the case of the mass triage sensors these could either connect individually, through their own gateway or through the patient’s existing BAN hub / gateway.
In addition to ambulances on the ground, helicopter ambulances are also used. There are not many air ambulances available at present and their use is infrequent. This situation might change in the future particularly with respect to scenarios that reflect high economic growth. When on the ground, air ambulances can be regarded as equivalent to an ordinary ambulance and the comments above regarding a possible network architecture would apply. In the air, however, Air Traffic Control and VHF channels to connect to other services are used and multiple handsets for the different mobile networks are carried to ensure connectivity in all locations. In the event that air ambulances become more widespread a review of their connectivity requirements could be appropriate.
6.4 At Home Applications

6.4.1 At Home Applications - Characteristics

While many of the applications relating to an individual have been addressed earlier (paragraphs 6.4-6.6), when that individual is considered to be located anywhere, most if not all of those applications will also be relevant to an individual in the home. The table below only lists those applications that are additional and specifically related to the home environment.

<table>
<thead>
<tr>
<th>At Home Application name</th>
<th>Ref</th>
<th>Communications Direction</th>
<th>Distance</th>
<th>Coverage type</th>
<th>Traffic type</th>
<th>Quality of service</th>
<th>Frequency of data transfer</th>
<th>Spectrum</th>
<th>Need for mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home hub and sensors</td>
<td>H 1</td>
<td>One way</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Data</td>
<td>Moderate but not critical</td>
<td>Quite frequent</td>
<td>Allocated</td>
<td>Stationary</td>
</tr>
<tr>
<td>Video conferencing</td>
<td>H 2</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional (&lt;100km)</td>
<td>Video</td>
<td>Moderate but not critical</td>
<td>Occasional</td>
<td>Wired</td>
<td>Stationary</td>
</tr>
<tr>
<td>Interactive computerised therapy</td>
<td>H 3</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional (&lt;100km)</td>
<td>Images</td>
<td>Store and forward best efforts</td>
<td>Occasional</td>
<td>Wired</td>
<td>On the move</td>
</tr>
<tr>
<td>Visiting doctor's bag / PDA</td>
<td>H 4</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional (&lt;100km)</td>
<td>Video</td>
<td>Moderate but not critical</td>
<td>When needed</td>
<td>Licence exempt</td>
<td>One the move</td>
</tr>
</tbody>
</table>
### At Home Applications - Usage

The usage and connectivity of the applications relating specifically to the home environment are listed below:

<table>
<thead>
<tr>
<th>#</th>
<th>At Home Application Name</th>
<th>Total addressable market</th>
<th>Age of Abundance</th>
<th>Health makes good</th>
<th>Divergence</th>
<th>Everything in moderation</th>
<th>in Stagnation</th>
</tr>
</thead>
<tbody>
<tr>
<td>H 1</td>
<td>Home Hub and Sensors</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wireless</td>
<td>Wireless</td>
<td>Wireless</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H 2</td>
<td>Video conferencing</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wired</td>
<td>Wired</td>
<td>Wired</td>
<td></td>
<td>Wireless</td>
</tr>
<tr>
<td>H 3</td>
<td>Interactive Computerised Therapy</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wired</td>
<td>Wired</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H 4</td>
<td>Visiting doctor's bag / PDA</td>
<td>Niche</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wireless</td>
<td>Wireless</td>
<td>Wireless</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### At Home Applications – Analysis

Given the timeframe that this study is addressing it is assumed that in most cases the home will have a broadband connection and its own LAN which may or may not be wireless. The additional applications would be accommodated over the broadband connection via a wired and/or wireless LAN, and the other applications associated with an individual (especially the Body Area Network hub / gateway) would also interface to the broadband connection wirelessly or, where this is not available, over the public cellular network. An alternative architecture might use femtocells should these develop into a ubiquitous technology.

Similarly, if a GP were to visit a patient’s home, it might be expected that the doctor’s “electronic bag” or PDA would interface to home broadband connection wirelessly or, where this is not available, over the public cellular network.
6.5 Hospital and Primary Care Applications

6.5.1 Hospital and Primary Care Applications – Characteristics

The applications in hospitals and primary care are listed in the table below:

<table>
<thead>
<tr>
<th>Hospital and Primary Care Application name</th>
<th>Ref</th>
<th>Communications</th>
<th>Distance</th>
<th>Coverage type</th>
<th>Traffic</th>
<th>Quality of service</th>
<th>Frequency of data transfer</th>
<th>Spectrum</th>
<th>Need for mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFID to track assets</td>
<td>M 1</td>
<td>One way</td>
<td>One to one</td>
<td>RFID (&lt;150m)</td>
<td>Data</td>
<td>Moderate but not critical</td>
<td>Quite frequent (approx. every 5 minutes)</td>
<td>Allocated</td>
<td>On the move</td>
</tr>
<tr>
<td>RFID to track patients</td>
<td>M 2</td>
<td>One way</td>
<td>One to one</td>
<td>RFID (&lt;150m)</td>
<td>Data</td>
<td>Moderate but not critical</td>
<td>Quite frequent (approx. every 5 minutes)</td>
<td>Allocated</td>
<td>On the move</td>
</tr>
<tr>
<td>RFID to track staff</td>
<td>M 3</td>
<td>One way</td>
<td>One to one</td>
<td>RFID (&lt;150m)</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>Quite frequent (approx. every 5 minutes)</td>
<td>Allocated</td>
<td>On the move</td>
</tr>
<tr>
<td>RFID and pharmaceutical</td>
<td>M 4</td>
<td>One way</td>
<td>One to one</td>
<td>RFID (&lt;150m)</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>Infrequent (passive when scanned only)</td>
<td>Allocated</td>
<td>On the move</td>
</tr>
<tr>
<td>Mobile communication device</td>
<td>M 5</td>
<td>Both ways</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Voice</td>
<td>Moderate but not critical</td>
<td>Ad hoc (depends how often people want to talk to each other)</td>
<td>Allocated</td>
<td>On the move</td>
</tr>
<tr>
<td>Hospital and Primary Care Application name</td>
<td>Ref</td>
<td>Communications</td>
<td>Distance</td>
<td>Coverage type</td>
<td>Traffic type</td>
<td>Quality of service</td>
<td>Frequency of data transfer</td>
<td>Spectrum</td>
<td>Need for mobility</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-----</td>
<td>----------------</td>
<td>----------</td>
<td>---------------</td>
<td>-------------</td>
<td>-------------------</td>
<td>--------------------------</td>
<td>----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Remote presence Robots</td>
<td>M 6</td>
<td>One way</td>
<td>One to one</td>
<td>Regional &lt;100km</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data / video</td>
<td>Immediate and critical</td>
<td>Very (pretty much continuous stream of data would be needed)</td>
<td>Wired</td>
</tr>
<tr>
<td>Diagnostic tests at the bedside</td>
<td>M 7</td>
<td>One way</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, urban and rural</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>When needed</td>
<td>Licence exempt</td>
</tr>
<tr>
<td>PACS</td>
<td>M 8</td>
<td>One way</td>
<td>One to one</td>
<td>LAN (150m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Images</td>
<td>Moderate but not critical</td>
<td>Occasional</td>
<td>Licence exempt</td>
</tr>
<tr>
<td>Clinician PDAs</td>
<td>M 9</td>
<td>Both ways</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, urban and rural</td>
<td>Video</td>
<td>Store and forward best efforts</td>
<td>Frequent – potentially constant if video streaming</td>
<td>Licence exempt</td>
</tr>
<tr>
<td>Research database</td>
<td>M 10</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional (&lt;00km)</td>
<td>Indoor</td>
<td>Images</td>
<td>Store and forward best efforts</td>
<td>Frequent</td>
<td>Wired</td>
</tr>
<tr>
<td>Vital sign monitoring at the bedside</td>
<td>M 11</td>
<td>One way</td>
<td>One to one</td>
<td>BAN (&lt;10)</td>
<td>Indoor, urban and rural</td>
<td>Data</td>
<td>Immediate and critical</td>
<td>Continuous</td>
<td>Allocated</td>
</tr>
<tr>
<td>Diagnostic body area networks</td>
<td>M 12</td>
<td>One way</td>
<td>One to one</td>
<td>BAN (&lt;10m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Images / video</td>
<td>Moderate but not critical</td>
<td>Quite frequently (approx. every 5 mins)</td>
<td>Allocated</td>
</tr>
<tr>
<td>Re-programming of in-body sensors</td>
<td>M 13</td>
<td>Both ways</td>
<td>One to one</td>
<td>BAN (&lt;10m)</td>
<td>Indoor, urban and rural</td>
<td>Data</td>
<td>Moderate but not critical</td>
<td>Continuous</td>
<td>Allocated</td>
</tr>
<tr>
<td>Hospital and Primary Care Application name</td>
<td>Ref</td>
<td>Communications</td>
<td>Distance</td>
<td>Coverage type</td>
<td>Traffic type</td>
<td>Quality of service</td>
<td>Frequency of data transfer</td>
<td>Spectrum</td>
<td>Need for mobility</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-----</td>
<td>----------------</td>
<td>----------</td>
<td>---------------</td>
<td>-------------</td>
<td>-------------------</td>
<td>----------------------------</td>
<td>----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Room clean sensors</td>
<td>M 14</td>
<td>One way</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Store and forward best efforts</td>
<td>Quite frequently (approx every 10 minutes)</td>
<td>Wired</td>
</tr>
<tr>
<td>Smart cards</td>
<td>M 15</td>
<td>One way</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Immediate and critical</td>
<td>Whenever needed</td>
<td>Wired</td>
</tr>
<tr>
<td>Electronic prescription services</td>
<td>M 16</td>
<td>One way</td>
<td>One to one</td>
<td>PAN (&lt;10m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Moderate but not critical</td>
<td>When needed</td>
<td>Licence exempt</td>
</tr>
<tr>
<td>NHS Care records</td>
<td>M 17</td>
<td>Both ways</td>
<td>One to one</td>
<td>Regional &lt;100km</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Images</td>
<td>Moderate but not critical</td>
<td>Occasional</td>
<td>Wired</td>
</tr>
<tr>
<td>Internet connectivity for patients and</td>
<td>M 19</td>
<td>Both ways</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, urban and rural</td>
<td>Video</td>
<td>Store and forward best efforts</td>
<td>Very frequent</td>
<td>Licence exempt</td>
</tr>
<tr>
<td>Mobile interpretation services</td>
<td>M 20</td>
<td>Both ways</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Voice</td>
<td>Moderate but not critical</td>
<td>Continuous</td>
<td>Licence exempt</td>
</tr>
<tr>
<td>Equipment status monitoring</td>
<td>M 21</td>
<td>Both ways</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Data</td>
<td>Moderate but may be critical – eg a life support machine</td>
<td>Very frequent</td>
<td>Licence exempt</td>
</tr>
<tr>
<td>Ultra stethoscope</td>
<td>M 22</td>
<td>One way</td>
<td>One to one</td>
<td>LAN (&lt;150m)</td>
<td>Indoor, outdoor, urban and rural</td>
<td>Video</td>
<td>Moderate but not critical</td>
<td>Fairly frequent</td>
<td>Licence exempt</td>
</tr>
</tbody>
</table>
### Hospital and Primary Care – Usage

The usage and connectivity of the applications relating to the hospital and primary care are listed below. It is assumed that even within the Age of Abundance scenario where wireless facilities are present there will still be a wired infrastructure both within and between hospitals not only to integrate the wireless facilities but also to provide reliable transport for the significant amounts of data associated with digital imaging.

<table>
<thead>
<tr>
<th>#</th>
<th>Hospital and Primary Care Application Name</th>
<th>Maximum addressable market</th>
<th>Age of Abundance</th>
<th>Health service makes good</th>
<th>Divergence</th>
<th>Everything in moderation</th>
<th>Stagnation</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 1</td>
<td>RFID to track assets</td>
<td>Moderate</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Low Wireless</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>M 2</td>
<td>RFID to track patients</td>
<td>Niche</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Medium Wireless</td>
<td>Low Wireless</td>
<td>n/a</td>
</tr>
<tr>
<td>M 3</td>
<td>RFID to track staff</td>
<td>Moderate</td>
<td>High Wireless</td>
<td>Medium Wireless</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>M 4</td>
<td>RFID and pharmaceutical</td>
<td>Significant</td>
<td>High Wireless</td>
<td>n/a</td>
<td>Low Wireless</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>M 5</td>
<td>Mobile communication device</td>
<td>Niche</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Low Wireless</td>
<td>Low Wireless</td>
<td>Low Wireless</td>
</tr>
<tr>
<td>M 6</td>
<td>Remote presence robots</td>
<td>Niche</td>
<td>Medium Wired</td>
<td>Medium Wired</td>
<td>Low Wired</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>M 7</td>
<td>Diagnostic tests at the bedside</td>
<td>Niche</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Medium Wireless</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
## Health Technology Scenarios

<table>
<thead>
<tr>
<th>#</th>
<th>Hospital and Primary Care Application Name</th>
<th>Maximum addressable market</th>
<th>Age of Abundance</th>
<th>Health service makes good</th>
<th>Divergence</th>
<th>Everything in moderation</th>
<th>Stagnation</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 8</td>
<td>PACS</td>
<td>Niche</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wireless</td>
<td>Wireless</td>
<td>Wired</td>
<td>Wireless</td>
<td>Wireless</td>
</tr>
<tr>
<td>M 9</td>
<td>Clinician PDAs</td>
<td>Niche</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wireless</td>
<td>Wireless</td>
<td>Wired</td>
<td>Wireless</td>
<td>Wireless</td>
</tr>
<tr>
<td>M 10</td>
<td>Research Database</td>
<td>Maximum</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wired</td>
<td>Wireless</td>
<td>Wired</td>
<td>Wired</td>
<td>n/a</td>
</tr>
<tr>
<td>M 11</td>
<td>Vital sign monitoring at the bedside</td>
<td>Niche</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wireless</td>
<td>Wireless</td>
<td>Wired</td>
<td>Wired</td>
<td>n/a</td>
</tr>
<tr>
<td>M 12</td>
<td>Diagnostic body area networks</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wireless</td>
<td>Wireless</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M 13</td>
<td>Re-programming of in-body sensors</td>
<td>Niche</td>
<td>High</td>
<td>Medium</td>
<td>Yes</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wireless</td>
<td>Wired</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M 14</td>
<td>Room clean sensors</td>
<td>Niche</td>
<td>High</td>
<td>Medium</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wireless</td>
<td>Wired</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M 15</td>
<td>Smart cards</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wireless</td>
<td>Wireless</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M 16</td>
<td>Electronic Prescription Services</td>
<td>Significant</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wireless</td>
<td>Wireless</td>
<td></td>
<td></td>
<td>Wireless</td>
</tr>
</tbody>
</table>
## Health Technology Scenarios

### Hospital and Primary Care - Analysis

The potential ICT infrastructure across a hospital site to support the above applications can be characterised as follows:

- A RFID infrastructure for the tracking / labelling of all assets – equipment, drugs, staff and patients.
- A wireless infrastructure (e.g. WLAN access points) for connecting staff and patients (voice and data) and to allow diagnostic equipment to be made fully mobile.
- Wireless sensors potentially interfacing with the wireless infrastructure identified immediately above.

<table>
<thead>
<tr>
<th>#</th>
<th>Hospital and Primary Care Application Name</th>
<th>Maximum addressable market</th>
<th>Age of Abundance</th>
<th>Health service makes good</th>
<th>Divergence</th>
<th>Everything in moderation</th>
<th>Stagnation</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 17</td>
<td>NHS care records</td>
<td>Niche</td>
<td>High Wired</td>
<td>High Wired</td>
<td>High Wired</td>
<td>Medium Wired</td>
<td>Low Wired</td>
</tr>
<tr>
<td>M 18</td>
<td>Patient video displays</td>
<td>Niche</td>
<td>High Wired</td>
<td>Medium Wired</td>
<td>Low Wired</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>M 19</td>
<td>Internet connectivity for patients</td>
<td>Niche</td>
<td>High Wireless</td>
<td>Medium Wireless</td>
<td>Low Wireless</td>
<td>Low Wired</td>
<td>n/a</td>
</tr>
<tr>
<td>M 20</td>
<td>Mobile interpretation services</td>
<td>Maximum</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Low Wireless</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>M 21</td>
<td>Equipment status monitoring</td>
<td>Moderate</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>Low Wireless</td>
<td>Low Wireless</td>
<td>n/a</td>
</tr>
<tr>
<td>M 22</td>
<td>Ultrasound stethoscope</td>
<td>Moderate</td>
<td>High Wireless</td>
<td>High Wireless</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Facilities to interface the BANs of individuals with diagnostic equipment (and potentially to the wireless infrastructure identified above).

6.6 Summary

In summary the wireless networking sub-systems that might be expected to develop in order to support these applications are:

1. Body area networks including a personal gateway (including interfaces to public networks, ambulance network, hospital network, home network)
2. Ambulance wireless LAN including a gateway to public safety network (Airwave)
3. Home wireless LAN including a gateway to broadband connection (wired or future public wide area wireless system – 4G)
4. Hospital wide (& GP surgeries/polyclinics) wireless LAN with gateway to wired infrastructure.
5. Hospital wide (& GP surgeries/polyclinics) RFID system – extent of requirement depends partly on whether patients’ records are held on personal RFIDs or are associated with the BAN gateway.
7 Implications for Spectrum

7.1 Introduction
This section describes the networks and spectrum required to support the ICT applications that are described in each of our five scenarios. It starts with an extensive description of the maximum possible requirement for networks and spectrum. It then compares each of our five scenarios against this “Maximum Spectrum Implications”.

7.2 Maximum Spectrum Implications
This section gives our viewpoint on the networks and spectrum necessary to comfortably and safely support the maximum possible usage of ICT health applications. It assumes that all the applications listed in section 5 see the greatest possible usage.

7.2.1 Infrastructure and Wireless Implementations of each location
The following table shows the infrastructure elements and a full list of the potential wireless implementations for each of the four locations.

<table>
<thead>
<tr>
<th>Location</th>
<th>Infrastructure elements</th>
<th>Potential wireless implementations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual / anywhere</td>
<td>(In and on) Body Area Network (BAN)</td>
<td>In-body - proprietary solutions using spectrum near 400 MHz or near field communications at lower frequencies. On-body – Bluetooth, Zigbee, UWB. Possible future IEEE standard and/or Bluetooth profile.</td>
</tr>
<tr>
<td></td>
<td>BAN interface to other networks (personal hub, potentially including processing power and electronic storage)</td>
<td>Interface to LAN (public / private): cellular networks, WiMAX. UWB / Bluetooth to mobile phone (and onwards over mobile or other networks). Frequencies specific to healthcare (e.g. social alarms and, if implemented as recommended, medical telemetry).</td>
</tr>
<tr>
<td>Mobile phone / PDA</td>
<td></td>
<td>Messaging, stills and video by connecting to cellular networks, WiMAX or LAN (public / private).</td>
</tr>
<tr>
<td>RFID (Patient’s record, but might alternatively be stored by the personal hub – see above)</td>
<td></td>
<td>Harmonised frequencies near 867 MHz and at the centre of the 2.4 GHz ISM band.</td>
</tr>
<tr>
<td>Ambulance</td>
<td>(In and on) Body Area Network</td>
<td>In-body: proprietary solutions using spectrum near 400 MHz or near field communications at lower frequencies.</td>
</tr>
<tr>
<td><strong>Health Technology Scenarios</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(BAN) – the individual’s and/or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>network of mass triage sensors.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MHz or near field communications at lower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>frequencies.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-body: Bluetooth, Zigbee, UWB.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible future IEEE standard and/or Bluetooth profile.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BAN and/or mass triage sensor network interface.</td>
<td>To ambulance LAN including, if implemented as recommended, medical telemetry frequencies.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potentially, also to other wireless networks for redundancy.</td>
<td></td>
</tr>
<tr>
<td>Local Area Network (LAN)</td>
<td>2.4 GHz and / or 5 GHz.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Also medical telemetry frequencies if implemented as recommended.</td>
<td></td>
</tr>
<tr>
<td>LAN interface to other networks (ambulance hub)</td>
<td>To wide area mobile networks e.g. Airwave and / or public mobile networks, including their evolution to support quality video.</td>
<td></td>
</tr>
<tr>
<td>Mobile phone / PDA</td>
<td>Messaging, stills and video by connecting to cellular networks, WiMAX or LAN (public / private).</td>
<td></td>
</tr>
<tr>
<td>RFID reader</td>
<td>Harmonised frequencies near 867 MHz and at the centre of the 2.4 GHz ISM band.</td>
<td></td>
</tr>
<tr>
<td><strong>In the home</strong></td>
<td>(In and on) Body Area Network (BAN)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In-body - proprietary solutions using spectrum near 400 MHz or near field communications at lower frequencies.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>On-body – Bluetooth, Zigbee, UWB.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Possible future IEEE standard and/or Bluetooth profile.</td>
<td></td>
</tr>
<tr>
<td>BAN interface to other networks (personal hub, potentially including processing power and electronic storage)</td>
<td>To home LAN / hub, cellular networks, WiMAX.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UWB / Bluetooth to mobile phone (and onwards over mobile or other networks).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequencies specific to healthcare (e.g. social alarms and, if implemented as recommended, medical telemetry).</td>
<td></td>
</tr>
<tr>
<td>Local Area Network (LAN)</td>
<td>2.4 GHz and / or 5 GHz.</td>
<td></td>
</tr>
<tr>
<td>LAN interface to other networks (home hub)</td>
<td>Wired</td>
<td></td>
</tr>
<tr>
<td>Mobile phone / PDA</td>
<td>Messaging, stills and video by connecting to cellular</td>
<td></td>
</tr>
</tbody>
</table>
Health Technology Scenarios

### In the hospital

| RFID reader | Harmonised frequencies near 867 MHz and at the centre of the 2.4 GHz ISM band. |
| In-body - proprietary solutions using spectrum near 400 MHz or near field communications at lower frequencies. |
| On-body – Bluetooth, Zigbee, UWB. |
| Possible future IEEE standard and/or Bluetooth profile. |

| (In and on) Body Area Network (BAN) | In-body - proprietary solutions using spectrum near 400 MHz or near field communications at lower frequencies. |
| On-body – Bluetooth, Zigbee, UWB. |
| Possible future IEEE standard and/or Bluetooth profile. |

| BAN interface | To hospital LAN including, if implemented as recommended, medical telemetry frequencies. |
| Potentially, also to other wireless networks for redundancy. |

| Local Area Network (LAN) | 2.4 GHz and/or 5 GHz. |
| Also medical telemetry frequencies if implemented as recommended. |

| LAN interface to other networks | Wired. |

| Individual monitoring devices | Wired or connect via the LAN (see above) – most likely to use dedicated telemetry frequencies. |

| Sensors | Wired or connect via the LAN (see above) – most likely to use standard WLAN LE spectrum. |

| RFIDs (relating to all assets: equipment, drugs, staff and patients) | Harmonised frequencies near 867 MHz and at the centre of the 2.4 GHz ISM band. |

### 7.2.2 Role of public and private third party networks

Even in this maximum scenario, most of the wireless requirements could be supported by public and private third party networks. The key networks are as follows:

- Cellular networks will readily transfer general information and support transactions between individuals (including their body area networks), doctors and health centres. In the longer term, taking account of the possible introduction of WiMAX and the Long Term Evolution (LTE) of IMT, it is anticipated that video of sufficient quality will be supported.

- The Airwave Tetra network has been provided for the exclusive use of emergency and public safety organisations and personnel. The current network provides voice and relatively low bit rate data

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16 Sufficient quality should be taken to mean the provision of video containing enough detail to make accurate diagnostic judgements.
Health Technology Scenarios

capabilities and there are no publicly available plans as to how the network would evolve to accommodate the data rates associated with high quality video within the spectrum currently available. Therefore it is possible that a dedicated WiMAX or LTE network might be required to support the sharing of video between ambulances and hospitals. While it is always possible to increase the density of base stations in order to increase capacity, it is probable that any significant demand for video will have an impact on spectrum requirements bearing in mind that current processes only deal with the transfer of small amounts of data.

- Wireless LANs operating in the 2.4 and/or 5 GHz bands. These could provide wireless infrastructure in several locations including hospitals, around ambulances and in individual’s homes. The 2.4 GHz band continues to be popular leaving the extensive spectrum at 5 GHz sparsely used.

- Bluetooth and Ultra Wide Band (UWB) are relatively short range technologies but will still provide useful links between the various sub-networks that will exist in the future. For example, connectivity between a body area network and a wide area cellular network would be satisfied efficiently by a Bluetooth or UWB link between an individual’s body area network gateway/hub and their mobile phone.

- RFIDs are specifically provided for in the 865-868 MHz band (15 channels) and in the centre of the 2.4 GHz ISM band\textsuperscript{17}. Operation in these bands is at a relatively high power and there are some controls on the duty cycle. RFIDs could be used to track and hold information about a wide range of assets – drugs, equipment, patients and staff. It should be noted however that it is not the only technology that provides location awareness but today it is probably the most standardised.

In terms of the spectrum used by third parties (i.e. network operators) it can be noted that there is a knock-on effect from the systems deployed by the health sector. In particular, if video is to be used extensively at scenes attended by ambulances then there will clearly be an additional burden on the network connecting an ambulance to a hospital. The requirement for additional spectrum to support this will depend on a number of factors outside the control of the health sector. It can be expected that the network operators themselves will obtain any additional spectrum that might be required through the usual channels.

Finally, with regard to systems that use spectrum commons (e.g. RFIDs and WLANs), it is possible that there will be congestion. In the case of RFIDs the technology has not been widely deployed and in those cases where it is used in other sectors (e.g. the retail supply chain) there have been mixed reports (see Computer Weekly, various, 2006) regarding interference. It is not known whether the interference is due to congestion or poor system deployment. If the cause is congestion, then a significant deployment within the health sector would be expected to suffer the same problem. Resolution of this problem, if real and widespread in other sectors, by way of additional spectrum would probably occur at international level, i.e. through ETSI and CEPT.

7.2.3 Systems which require dedicated spectrum

When considering whether new and exclusive spectrum should be provided, it is necessary to address the justification as to why such provision should be made. The main (and arguably sole) reason that exclusive

\textsuperscript{17} Numerous other non-specific bands are available but RFID operation in these is generally limited to much lower power levels and therefore mainly appropriate to very localised operations.
spectrum should be made available is for those cases where communication link failure due to interference puts a patient’s life at risk and in particular for situations where time is of the essence. Of all the applications considered in preceding sections there are only a few which fall into this category:

1. **LANs supporting links with BANs.** Links between body area networks and other equipment where this other equipment takes on the responsibility for monitoring vital signs and/or administering drugs. This could be in hospital intensive care or relate to ambulance equipment at the scene of an accident.

2. **Body area networks** when monitoring vital signs and/or administering drugs.

3. **Social alarms for monitoring** activities of daily living in isolated or socially-excluded groups (the most common use-case is alarms to monitor falls of older people). This could be extended to the remote monitoring of body area networks but the backhaul is likely to be carried by a public network (i.e. only the local radio link would be supported by exclusive spectrum).

It can be noted that there is one application where the risk to the patient’s life is so great that a wired solution is arguably most appropriate, namely remote controlled robotic operations.

**LANs supporting links with BANs**

Local area networks (both hospital and ambulance based) are the supporting links between body area networks and diagnostic equipment, and/or between diagnostic equipment and communications gateways. It is possible that these could be provided by conventional Wireless LAN technology at 2.4 or 5 GHz as noted above. However, there is a risk of interference to these networks which, for the more critical telemetry streams could be potentially life threatening. Even if the clinical environment seeks to control the interference within their buildings and vehicles, it could still be problematic for ambulances creating WLANs outside of their vehicle, for example at a road traffic accident. We recommend, therefore, that the more critical telemetry streams should be supported by dedicated spectrum. The FCC Wireless Medical Telemetry Service (WMTS) uses the bands 608 – 614 MHz, 1395 – 1400 MHz and 1427 – 1432 MHz. There is no equivalent allocation at the CEPT level nor in the UK. New bands of spectrum for critical medical telemetry should be harmonised with Europe, the USA and the rest of the world.

In terms of the future provision of new dedicated spectrum within the UK the highest priority will be the wireless local area network application for hospitals and ambulances. Critical communication links (e.g. vital signs monitoring) will require new dedicated spectrum to reduce the possibility of interference that might be experienced if licence-exempt WLAN spectrum were to be used.

In terms of new dedicated spectrum there are three possibilities that can be considered:

- harmonisation with the US frequencies
- a band or bands at or near the 2.4 and 5 GHz WLAN frequencies given that much of this equipment already has tuning ranges of 2.3 – 2.5 GHz and 4.9 – 5.85 GHz
- a band or bands elsewhere in the spectrum

In the case of the first two options the amount of spectrum is largely determined by the degree of harmonisation involved. In the case of identifying an allocation elsewhere in the spectrum it can be noted that the bandwidth required is relatively small as the requirement is for low bit rate telemetry and the provision of a few narrow band radio channels to support multiple devices or individuals in an area (e.g. hospital ward). If the critical applications go beyond low bit rate telemetry to, for example, the use of
ultrasound stethoscopes providing moving images for diagnostic purposes (both hospital and ambulance based), then the provision of dedicated spectrum might have to be more extensive than a few narrow band radio channels.

Less critical communication links can still use licence-exempt WLAN spectrum and, taking account of the availability of 5 GHz WLAN spectrum, it is not foreseen that there will be a shortage of spectrum for these less critical communication links.

**BANS**

Body area networks supporting implanted devices are sometimes used to deliver accurate doses of drug therapy directly into the patient. The criticality of this function means that dedicated spectrum is required - interference could cause errors that, in some cases, prove to be fatal.

Within the UK there is no requirement to allocate new spectrum to medical implants as there is already a CEPT allocation for medical implants at 402 – 405 MHz which the UK has implemented, and is the same as the FCC Medical Implant Communications Service (MICS) allocation in the US. The CEPT allocation has recently been extended by 1 MHz at either end of the existing band. It is thought that this extension is due to “apparent” congestion caused by competing technologies rather than inherent congestion due to current or foreseen demand.

It seems to us that this allocation will be sufficient to cover foreseeable new applications. However, the situation should be kept under review.

**Social Alarms**

Social alarms are well established and because provision is already made at a CEPT level (and reflected in UK allocations) near 170 MHz and near 870 MHz there is no requirement for new dedicated spectrum. Four channels are nominally available, 2 of which are for exclusive use, and the maximum power level and duty cycle are low. Given the emergency nature of these devices and their controlled power level / duty cycle the likelihood of congestion is low. This is especially so since they tend to be used in residential areas where the density of use is low.

However, Ofcom or an appropriate body within the health sector should monitor the situation to determine when congestion might occur. In the event that additional spectrum is required it is likely to be in small amounts, although if the requirement is for contiguous spectrum (with respect to existing allocations), it may be more difficult to make provision without displacing existing users.

### 7.3 The Implications for Spectrum in each of the Scenarios

As a reminder, a summary description each of the scenarios has been included as an introduction to each of their subsections; a detailed account can be found in section 4.
The first scenario, Age of Abundance, relates directly to the “Maximum Spectrum Implications” discussed in the preceding section (7.2). The spectrum implications of the subsequent scenarios are discussed in relation to the “Maximum Spectrum Implications” – that is to say, for a given scenario one starts with the “Maximum Spectrum Implications” and then reduces (in general) the spectrum requirement in line with the text for that scenario (see below).

### 7.3.1 Age of Abundance

This scenario shows the most positive scenario in the future of the health service. Innovative technology solutions have enabled the NHS to consistently deliver a high quality service. The ‘centralise where necessary, localise where possible’ vision has been implemented successfully and information is widely valued and leveraged.

This scenario sees the maximum usage of ICTs in healthcare. Therefore the implications for spectrum in this scenario are exactly as described in the “Maximum Spectrum Implications” section above.

### 7.3.2 Divergence

This scenario shows a situation where technological progress is high but the NHS does not make the best use of applications available. There are pockets of innovation and change but national strategies are limited as the majority of funding is consumed by the almost unsustainable wage bill. Much of the uptake and innovation of wireless ICTs in healthcare is driven by individuals, supplied by private firms and for outside the NHS.

Its key difference from the “Maximum Spectrum Implications” is that there will be a distinction between the “haves” and “have nots” at all levels. For example, there are expected to be fewer individuals (just the wealthy ones) with body area networks, and at the same time ambulances and hospitals may not have the equipment required to support all the applications we see in the “Maximum Spectrum Implications”. Whilst the technology may be successfully deployed in a sporadic and local way, the nationwide effectiveness of ICTs in healthcare will be significantly reduced.

The amount of dedicated health spectrum required is mostly determined by density of users in relation to the various locations that have been considered. It is expected that this scenario will have the same density of users as the “Maximum Spectrum Implications”, but only at some locations and not at others (i.e. less uniform usage as noted above). This implies that the same amount of spectrum will be required but that the spectrum will not be used everywhere. This, coupled with the fact that technological developments may not be standardised across the country (or with respect to international developments) may give rise to the impression that spectrum is not being used to its fullest effect.

### 7.3.3 Health service makes good

This scenario is also a largely positive scenario. However, in this scenario the NHS makes excellent use of available technology in order to compensate for the reduction in economic growth and funding.
The key difference between this scenario and the “Maximum Spectrum Implications” is that there is more personal responsibility and consequently a potentially greater uptake of body area networks. At the same time there is a marginally lower uptake of some data-light applications and the non-appearance of a few other applications such as nutritional content scanning associated with individuals and the use of RFIDs by the pharmaceutical industry. Overall though, from a spectrum point of view there is little difference between this scenario and the “Maximum Spectrum Implications”.

The implication for radio spectrum usage is that there is likely to be:

- More pressure on body area network spectrum and therefore the recommendation that Ofcom or an appropriate body within the health sector should monitor the situation to determine when congestion might occur applies to an even greater extent here compared to the “Maximum Spectrum Implications” of the Age of Abundance scenario.
- Little difference with respect to other spectrum, except perhaps less pressure on RFID spectrum because of the foreseen lack of widespread deployment by the pharmaceutical industry.

7.3.4 Everything in moderation

This scenario assumes that the NHS will make some moves towards utilising available technology, but that it will be largely hampered by the lower economic growth. Whilst there are areas that will see progress and innovation, it will be at a slower rate than envisaged.

Its key differences with respect to the “Maximum Spectrum Implications” are that there is a lower uptake of those applications that are deployed and some of these applications will appear in a simpler form. For example, the body area network is likely to be limited to in or on body monitoring without in body drug delivery. Furthermore, the network may not be a network as such if only single devices are deployed.

A number of applications will potentially not make it to deployment. For example, the visiting doctor’s bag (electronic) will not be rolled out and on-body / in-body mass triage sensors will not be available to paramedics. However, there is still likely to be deployment of wireless based vital sign monitoring at the bedside in hospitals and potentially a degree of the same with respect to ambulances.

The implication for radio spectrum usage is that:

- Overall there is a far lesser requirement for spectrum but a requirement still remains for most network architectures (if slightly simplified) at all locations.
- In particular there is still a requirement for new dedicated spectrum to support critical data links in hospitals and with respect to ambulances.

7.3.5 Stagnation

This is the most negative scenario. A combination of low economic growth and technological progress lead us to a
There are two key differences with respect to the “Maximum Spectrum Implications”. The first is that only a few of the applications will be deployed on a wide scale. These are likely to be the ones where there is already evidence of their development if not yet deployment. In short the technology for these applications largely already exists but in the stagnation scenario, wide scale deployment is very slow, or even indefinitely delayed. Examples of applications which would be unlikely to be supported in this scenario are the wireless support of in-body monitoring even in its simplest form and the use of RFIDs in hospitals for any sort of tracking. The second key difference is that the number of social alarms required could in fact increase in this scenario. High morbidity, the ageing population and the lack of preventative applications may lead to a situation where more reactionary applications such as social alarms are needed.

The implication for radio spectrum usage is that:

- There may be increased pressure on spectrum allocated to social alarms and this should be monitored to assess when congestion might occur
- Little else needs to be done with regard to further radio spectrum provision. It is assumed that all the applications that potentially require new spectrum (e.g. vital sign monitoring at the bedside or in the ambulance) will continue to be supported by wires rather than wirelessly
7.4 Shocks and implication for spectrum

With reference to the shocks described earlier in this report, it is possible to identify what impact these shocks would have on the various applications we have been considering and therefore what the implications are for spectrum usage.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Shock name</th>
<th>Application characterisation</th>
<th>Implication for spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flu pandemic</td>
<td>Density of application use in hospitals unlikely to change but room clean sensors likely to assume greater importance. Greater use of home care and need for advice and medicines - increase in comms applications therefore.</td>
<td>Minimal implications for spectrum. Impact would largely be on third party network capacity (i.e. mobile phones) and internet connections which are mainly wired.</td>
</tr>
<tr>
<td>2</td>
<td>Labour shortage</td>
<td>Fewer wireless applications in hospitals – only those demonstrating short term benefits implemented. Greater use of home care (as above) and therefore increase in comms applications.</td>
<td>Possibly reduced use of spectrum in hospitals and in residential areas, increased demand on public and third party network capacity (i.e. mobile phones) and internet connections which are mainly wired.</td>
</tr>
<tr>
<td>3</td>
<td>Major data security breach</td>
<td>Reduced level of application uptake – especially those relating to individuals’ records. Other applications (e.g. vital signs monitoring wirelessly) unaffected.</td>
<td>Less data being transferred but many applications still implemented with reduced functionality or using different technology (e.g. use of RFID’s solely for location awareness and without a significant data payload).</td>
</tr>
<tr>
<td>4</td>
<td>Technology breakthroughs</td>
<td>Increased use of body area networks.</td>
<td>With increased numbers of in-body / on-body devices and denser use in terms of numbers of individuals, the limited number of channels available may prove inadequate. This has already been identified as a possible issue with respect to the “Maximum Spectrum Implications” and Age of Abundance scenario.</td>
</tr>
<tr>
<td>5</td>
<td>Disaster</td>
<td>Concentration of ambulances in a relatively small area. Interoperability (and with other</td>
<td>Likely to overload wide area network capacity in that area – arrangements need to be made with and by third party network operators (i.e.</td>
</tr>
</tbody>
</table>


| services) a requirement. | Potential requirement for sub-ground communications. | Airwave and operators of public mobile networks) for their systems to provide enough capacity. In our view, the Access Overload Control (ACCOLC) arrangement is adequate, so long as it is implemented by the Mobile Operators. Interoperability potentially an issue in the diversity scenario. Ambulance LANs likely to interfere with one another unless coordinated and power levels controlled. It is felt that additional spectrum (over and above that identified for the scenarios) is not likely to be required if network management procedures are put in place to avoid interference. However, further research is required to be sure that this is the case. Facilities for supporting communications underground need to be negotiated for those locations most at risk (e.g. The London Underground). |
8 Summary of Conclusions and Recommendations

The health service is the UK is a very complicated system that could evolve in a number of different ways. We have illustrated possible evolutions over the next 10-20 years using five scenarios:

- Age of Abundance
- Divergence
- Health service makes good
- Everything in moderation
- Stagnation

Having assessed the use of applications within each scenario we were able to identify the different network infrastructures required for the applications. When considering whether any of these require designation of exclusive spectrum we concluded that exclusive spectrum should only be sought in cases where communication link failure due to interference puts a patient’s life at risk and in particular for situations where time is of the essence. The three types of applications that fall into this category are:

1. Body area networks when monitoring vital signs and / or administering drugs

2. Links between body area networks and other equipment where this other equipment takes on the responsibility for monitoring vital signs and / or administering drugs.

3. Social alarms for monitoring patients at home. This could be extended to the remote monitoring of body area networks but note that the backhaul is likely to be carried by a public network. (i.e. only the local radio link would be supported by exclusive spectrum).

The following illustrates the dedicated spectrum for each system:

<table>
<thead>
<tr>
<th>Application / network area requiring dedicated spectrum</th>
<th>Dedicated spectrum requirements / details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body area networks supporting implanted devices</td>
<td>There is already a CEPT allocation for medical implants at 402 – 405 MHz which the UK has implemented. The CEPT allocation has recently been extended by 1 MHz at either end of the existing band. This allocation should be adequate for the foreseeable future but kept under review.</td>
</tr>
<tr>
<td>Local area networks supporting links between body area networks and diagnostic equipment and / or between diagnostic equipment and communications gateways</td>
<td>It is possible that this could be supported using conventional WLAN technology at 2.4 or 5 GHz. However, more critical telemetry streams should be supported by dedicated spectrum. The FCC WMTS uses the bands 6-8</td>
</tr>
</tbody>
</table>
– 614 MHz, 1395 – 1400 MHz and 1427 – 1432 MHz. There is no equivalent allocation at the CEPT level or in the UK.

Social alarms

These are already well established and provision is already made at a CEPT level near 170 MHz and near 870 MHz. Given the emergency nature of these devices and their controlled power level / duty cycle the likelihood of congestion is low. However, Ofcom or an appropriate body within the health sector should monitor the situation to determine when congestion might occur.

In order to initiate policy decisions now, and without knowing which of the five scenarios will come about in 10-20 years, Ofcom will wish to understand the implications for spectrum across all the scenarios. For all but the most negative scenario ("Stagnation"), the implications for spectrum are largely similar. The demand for spectrum is highest in the Age of Abundance scenario, although there may be a greater need for body area network spectrum under the Health Service Makes Good scenario because of the high number of individuals taking personal responsibility for their health. However the implications for networks and for spectrum remains largely unchanged between the four most positive scenarios.

<table>
<thead>
<tr>
<th>Application / network area requiring dedicated spectrum</th>
<th>Age of Abundance</th>
<th>Divergence</th>
<th>Health service makes good</th>
<th>Everything in moderation</th>
<th>Stagnation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body area networks supporting implanted devices</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Local area networks supporting links between body area networks and diagnostic equipment and / or between diagnostic equipment and communications gateways</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Social alarms</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

Therefore we recommend that Ofcom should:
• Be aware that for all scenarios except Stagnation there is a requirement for new dedicated spectrum to support critical data links in hospitals, with respect to ambulance operations and at other health centres.

• Monitor the situation with respect to the utilisation of existing spectrum allocations for medical implants and social alarms. It is considered that existing allocations are adequate but there is a small risk of congestion in the most positive scenarios (Age of Abundance and Health service makes good) and, for social alarms, in the most negative scenario (Stagnation).

• Note that there is a consequent knock-on effect to third party networks and systems that use spectrum commons. Any requirement for additional spectrum, which is only likely to arise with the widespread and heavy use of high quality video links, would be expected to be made through the usual channels.

For the sector to realise the benefits of ICTs, the health sector (public and private providers and patient-representation) and the technology and telecommunications industry must work closely together. There may be a case for a task-force to bring together the stakeholders, to monitor use of health ICTs and spread “best-practice” examples of its use, and to collaborate to overcome the barriers which may hold back the sector’s technology development.

We recommend that the Department for Health (DH) should take more active responsibility for the use and management of radio spectrum by the health sector (and particularly by the NHS). This could involve the establishment of an organisation within the DH or the NHS to oversee and co-ordinate the use of spectrum, and more widely, all information and communications technologies. This organisation could also take an international oversight of health spectrum allocation in Europe, US and the rest of the world to monitor spectrum allocation and usage and ensure harmonisation where possible. Such an organisation would represent the NHS’s (and ultimately of course, the patient’s) interests in order to bring about the optimal use of wireless technologies.
9 Bibliography

Alzheimer Europe, link

An Introduction to RFID, Kabachinski, link

Authorities and Trusts, NHS Choices, July 2007, link

Better Health in Old Age, Department of Health, November 2004, link

Birmingham Heartlands Hospital Pilots World's First Wi-Fi Patient Tracking System to Improve Patient Care, ZDNet.co.uk, November 1999, link

Birmingham Heartlands RFID-tags patients to avoid litigation, British Journal of Healthcare Computing & Information Management, February 2005, link

Bluetooth website, link

Body sensor networks, Guang-Zhong Yang (Ed.), November 2005, link

Boss of troubled £12bn NHS computer project quits, Sunday Times, June 2007 link

Budget 2006-08, NI Department of Finance and Personnel, April 2006, link

Building telecare in England, Department of Health, June 2005, link

Building the modern NHS, Age Concern, June 2007 link

BUPA sells hospitals to private equity firm, Guardian, June 2007, link

BUPA website, link

Busting the myths of pharma RFID, A.T.Kearney, 2006, link

Can England learn from its neighbours?, Guardian, April 2006, link

Cardiac Telemedicine could save NHS £46m says report, 2007, link

Care of Elderly People, Market Survey, Laing & Buisson, 2006

Chief Scientific Officer Bulletin: Issue 1, Department of Health, May 2004, link

Circulatory diseases - leading cause group, Office of National Statistics, 2006, link

Collaborative research helps to ensure clean health care, NHS Connecting for Health, May 2007, link

Commission for Social Care and Inspection, link

Counterfeit Medicines Factsheet, World Health Organisation, November 2006, link

Creating a patient-led NHS: Delivering the NHS Improvement Plan, Department of Health, 2005, link

Data Flows, NHS Scotland Data Protection and Confidentiality, link

Decision to make The Wireless Telegraphy (Ultra-Wideband Equipment) (Exemption) Regulations 2007, Ofcom, July 2007, link
Delivering for Health, Executive Summary, Scottish Executive, 2005, link

Dental Charges, NI Central Services Agency, April 2007, link


Deprivation: General Discussion and Conclusions, NHS Scotland, link

Designed for Life, NHS Wales, December 2005, link

Diabetes Prevalence 2006, Diabetes UK, 2006, link

Diabetes: State of the Nations, 2005, link

Digital Healthcare: the impact of information and communication technologies on health and healthcare, Royal Society, 2006

Digital TV booking scheme for GPs, BBC News, July 2007, link

Distributed Innovation Processes and the Uneven Growth of Medical Knowledge, ESRC and MRC Innovative Health Technologies Project, 2005, link

DNA Microarray Fact Sheet, US National Human Genome Research Institute, January 2007, link

Doctor’s support of NHS National Programme for IT declines, Medix Survey quoted on Publictechnology.com, September 2005, link

Doubts over private clinic care, BBC News, July 2007, link

Enabling new wireless technologies in the UK, Ofcom, August 2007, link

European Radio Frequency Identification Tags Markets, Frost & Sullivan, December 2006, link

Exploiting the Electromagnetic Spectrum, DTI, 2004

Facts & Statistics from the pharmaceutical industry, ABPI, link

Focus on Health, Office of National Statistics, January 2006, link

Forecasting obesity to 2010, Department of Health, August 2006, link

Frequency Allocation Table, Ofcom, 2007, link

Funding Healthcare: 2008 and beyond, King’s Fund, 2007, link

Future trends, Future hospitals, Department of Health, Imison, 2005

Gene findings: Disease-by-disease, BBC News, June 2007, link

Gene Therapy, Human Genome Project, November 2005, link


General practitioners, dentists and opticians by region and NHS Strategic Health Authority, Office of National Statistics, September 2002, link
Global Care Quest Get Qualcomm 3G Healthcare Award, Wireless Healthcare, link
Global prevalence of dementia: a Delphi consensus study, Lancet, 2005, link
GP patient survey: your doctor, your experience, your say, Department of Health, July 2007, link
A Guide to ‘Extra Care’ Sheltered Housing in England, Elderly Accommodation Counsel, 2005
The Guide to Health Informatics, Coiera, October 2003, link
Has the NHS been successful?, Economics of Healthcare, link
Headline Figures 2005-06, Hospital Episode Statistics, 2006, link
Health Challenge Wales, NHS Wales / Welsh Assembly, link
Health Encyclopaedia, NHS Direct, June 2007, link
Health Insurance FAQ, healthinsurance.co.uk, July 2007, link
Health Policy Futures II Pathfinder Report Summary, Nuffield Trust and Judge Institute, Cambridge, 2004
Health Promotion Agency, Northern Ireland, link
Health Protection Agency website, link
Health Related Behaviour, Office of National Statistics, January 2004, link
Health Report, Office of National Statistics, 2006, link
Health risk and costs of obesity, Department of Health, March 2007, link
Health-service finances: On the mend, Economist, June 2007, link
Health Systems in Transition: the Northern Ireland report, European Observatory, 2006, link
Health Systems in Transition: the Welsh report, European Observatory, 2004, link
Health and Ten Years of Labour Government, Kings Fund, 2007, link
Health: Typical Employers, Prospects, Spring 2006, link
Healthcare Industries Task Force definition, Department of Health, July 2007, link
Healthcare RFID to track blood, Silicon.com, February 2006, link
Healthy life expectancy, World Health Organisation, 2002, link
History, Hospital Broadcasting Association, link
Hospital Activity Statistics, DH, March 2007, link
Hospital Waiting Times/List Statistics, Department of Health, 2007, link
Independence, well-being and choice: our vision for the future of social care for adults in England, Department of Health, 2005, link
Independent Sector Treatment Centres, Department of Health, 16 February 2006, link
Individual Budgets, Department of Health, May 2007, link
Information about local GP services, BMA, June 2007, link
Inpatient Waiting List 1997-present, Department of Health, 2005, link
Introduction to Healthcare & Medical, UK Trade & Investment website, July 2007, link
iPlato website, link
Jobs in the public sector, Office of National Statistics, 2003, link
Key Facts Workforce* Bulletin, Department of Health, Social Services & Public Safety, June 2007, link
Life expectancy at 65 reaches record level, Office of National Statistics, November 2006, link
Location Systems Could Offer Greater Precision, Data, Dempsey, 2003, link
Madingley Scenarios – two scenarios for the future context of healthcare, Ling, 2000
Main specialty: summary 2005-06, Hospital Episode Statistics, 2006, link
Main operations: summary 2005-06, Hospital Episode Statistics, 2006, link
Market Development Report, UK Medical Equipment, June 2006, link
Medical Devices Sector, EU Enterprise and Industry, link
N3 website, link
The National Programme for IT in the NHS, National Audit Office, 2006, link
National Workforce Plan 2006, Scottish Executive Health Department, 2006, link
New ambulance technology could save lives, East of England Ambulance Service NHS Trust link
New National NHS Direct Computer System to Benefit Patients, Department of Health, September 2000, link
NHS Allocations, Department of Health, July 2007, link
NHS Care Records Service, link
NHS Core Principles, NHS Choices, July 2000, link
NHS Dental Statistics for England, NHS Information Centre, November 2006, link
NHS Direct website, link
NHS Genetic Testing, Parliamentary Office of Science and Technology, 2004, link
NHS History, NHS Choices, link
NHS Staff 1995-2005 NHS Information Centre, April 2006, link
Nuffield Hospitals, link
O2 Airwave website, link
Older People, Office of National Statistics, 2005, link
101 Things To Do With a Mobile Phone in Healthcare, Wireless Healthcare, 2005, link
Organ Transplant, NHS Choices, link
Our Future Health Secured? A review of NHs funding and performance, Wanless, 2007
Our Health, Our Care, Our Say: A new direction for community services, Community Hospitals Association / Department of Health, link
Out-of-hours med care, Which?, May 2006, link
Patient Administration Services, Leeds Teaching Hospitals, September 2004, link
Patient Relationship Management in response to fragmented healthcare. A vision realised through technology, Protti, 2006, link
Pharmaceutical RFID - Fast Forward, IDTechEx, January 2006, link
Policy and Guidance: Foundation Trusts, Department of Health, February 2007, link
Policy Futures for UK Health, Nuffield Trust, 2000, link
Primary Care, Department of Health, 2007, link
Principaux Indicateurs Économiques, OECD, July 2007, link
Private Finance Initiatives, Department of Health, 2007, link
Private Surgery 'rip-off' costing NHS millions, the Observer, May 2003, link
Public Finances: Can England learn from its neighbours?, Guardian, April 2006, link
Public-Private Partnerships, Department of Health, 2007 link
Radio Restricted Service Licenses, Ofcom, July 2007, link
Rapid Adoption of RFID in healthcare, Harrop, 2006, link
Removal of patients from GP lists, BMA, April 2005, link
Report warns of £11 billion NHS funding gap, BUPA / NERA / Frontier, October 2006, link
Responding to the challenge of chronic diseases: lessons from England? EuroObserver, Summer 2005, link
RFID futures in western Europe, Juniper Research, January 2005, link
RFID hospital trials reach Europe, ZDNet, April 2005, link
RFID on drugs: Who will pay?, Silicon.com, March 2005, link
RFID trial tracks hospital, Computing, November 2006, link
Scottish Diet Action Plan, NHS Scotland, July 2007, link
Securing Good Care for Older People, King’s Fund, 2006, link
Securing Good Health for the Whole population, Wanless, 2004
Securing our Future Health: Taking a Long-Term View, Derek Wanless, 2002, link
Shaping health care for the next decade, Government News Network, July 2007, link
Sheltered Housing, Directgov, link
SHIFT Programme, NHS Connecting for Health Salford, January 2007, link
Specific Functions, Department of Health, 2007, link
Spectrum Framework Review, The Independent Audit of Spectrum Holdings, Ofcom, 2005
Staff in the NHS 2005, NHS Information Centre, 2006, link
Stem Cell Initiative, Department of Health, November 2005, link
Supercaring – the mid-life caring crisis?, SAGA, June 2006, link
Telemedicine and the ‘Future Patient’ Risk, Governance and Innovation, ESRC & MRC Innovative Health Technologies Project, 2004
The Electronic Patient Record, House of Commons Health Committee, 2007
The NHS Improvement Plan, Department of Heath, 2004
The NHS Plan, Department of Health, 2000
The Role and Effectiveness of Collaborative Knowledge Systems in Health Promotion and Health Support, ESRC & MRC Innovative Health Technologies Project, 2004, link
UK Interface Requirement 2030, Ofcom, November 2006, link
UK leads Europe in gene therapy trials, Department of Health, April 2005, link
Ultra-Wideband Breast Cancer Detection Radar, Modha, Dimitrakis, Hayes-Gill, and Harrison, 2007, link
Understanding the Market for eHealth, Silicon Bridge Research, 2001
Unreliable patients most likely to ask for SMS reminders, E-Health Insider, April 2005, link
Update on the Structure of the NHS in Wales, CAF, link
The Use of New Medical Technologies within the NHS, Fifth Report of Session 2004–05, Volume I, House of Commons Health Committee, April 2005, link
Vanguard Healthcare, link
Wi-Fi and RFID used for Tracking, BBC News, May 2007, link
Wi-Fi in Belfast hospital bags award, Techworld, June 2006, link
Wireless isn’t the future, it’s already with us, E-Health Insider, January 2006, link
Written Answers, Hansard, April 2001, link
Written Answers, Hansard, May 2004, link
Written Answers, Hansard, November 2005, link
Written Answers, Hansard, February 2007, link
ZigBee update: what’s in it for me?, Techworld, December 2005, link
10 Glossary

ACCOLC – access overload control is a scheme used in the UK to restrict the use of mobile telephones to key numbers in an emergency situation. Key numbers are limited to the emergency services, and they are responsible for registering them in advance.

Ageing population – increasing number of people over the age of 65 in relation to the younger working population

Application – a device that is part of, or enables the communication of information in some way. It could vary from a piece of software on a computer, an online program or a piece of hardware storing / processing the information

Barriers – refers to a force that acts on the health service which will discourage the use of ICTs over the next 20 years

Body Area Network – a network which contains nodes or sensors both on and within the body

Chronic disease – a disease that can usually be controlled but cannot be cured

Digital native – a person that grew up with digital technology from birth

Digital immigrant – a person that was already socialized in pre-digital methods before technology arrived

Discretionary healthcare – healthcare purchases made using disposable income. These purchases are made privately and would usually be in the field of preventative care.

Drivers – refers to a force that acts on the health service which will encourage the use of ICTs over the next 10-20 years

Drug therapy – refers to the use of drugs to treat disease, also known as pharmacotherapy

Electronic / online medical records – Medical records that are stored digitally (on the NHS Spine)

GENTEC – Genomic and proteomic technologies, gene antisense therapies

Health outcomes – based on the principle that every clinical intervention produces a change in the health status of the patient and that change can be measured

ICT (ICTEC) – Information and communication technologies

Information poor – people who have limited access to information. Usually they only information that they have access to is the information that they are given by the health practitioner

Information rich – people who have access to a wide range of information from different sources accessing the information using technology as well as other means

INR – International normalized ratio – a standardized way of measuring blood clotting

Internet forum – A web application for holding discussions and posting user generated content.

LAN – Local area network

Licence exempt spectrum – spectrum that can be used without the formal authorisation for a customer to use radio equipment
Lifestyle related illnesses – illnesses which are primarily caused by the behaviours or actions of the patients. For example, diseases related to obesity such as type 2 diabetes or alcohol-related illnesses.

MEDTEC – Medical devices and biomedical technology

MHz – Megahertz, a million Hz (cycles per second)

Morbidity – refers to the incidence or prevalence of all diseases and illness within a population.

N3 – provides the entire NHS with fast broadband networking services. It will facilitate programs such as the NHS Care Records Service

NHS Spine – Part of the National Programme for IT the NHS Spine will store all patient records as well as supporting systems such as Choose and Book and Electronic Prescription Service

Ofcom – UK regulator of the UK communications industries

Palliative care – relieving the symptoms of a disease without a cure including the after-care once someone has died

Pandemic – occurs over a wide geographic area and affects a high proportion of the population

Protocol – special set of rules that end points in a telecommunication connection use when they communicate

Peer-to-peer networks – where all computers on the network have the potential to share resources that they have control over

Polyclinic – a community based centre where GP surgeries and local hospital facilities are merged into one “super GP surgeries”

Health inequalities – the variation of health status by socio-economic status

Primary care – is a community based service which is usually the first point of contact that a patient makes with the health service. This includes: GPs, health visitors, district nurses, pharmacists dentists and midwives

RFID – Radio frequency identification

Secondary care – care which cannot take place within a GP practice, for example a patient will usually need to visit a hospital to get an x ray

Scenario – a postulated theory of the future

Social care – covers a wide range of services provided by local authorities and the independent and voluntary sectors. Social care comes in many forms, such as care at home, in day centres or by way of residential or nursing homes. The term also covers services such as providing meals on wheels to the elderly, home help for people with disabilities and fostering services. It does not include nursing care.

Social networking sites – websites that allow users to build online profiles. Users can share information such as photographs, blog entries, music tastes and clips and send messages to other users whom they are friends with. There are a number of general social networking sites such as Facebook and some where users have a similar interest, hobby, job etc.
Spectrum – refers the electromagnetic spectrum which encapsulates a continuous range of frequencies from radio waves to gamma rays

Shock – a revolutionary force which will act on the possible future scenarios

Telematics – blending of computers and wireless telecommunication technologies with the goal of efficiently conveying information over vast networks

Tertiary care - is the third and highly specialised stage of treatment, usually provided in a hospital centre which may not be local. A patient will generally be referred to tertiary treatment through secondary treatment, for example by a consultant in a hospital

WLAN – Wireless local area network
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