An STFC Strategy for Cancer
Playing our part

Science & Technology Facilities Council

> "Our vision for cancer is to contribute to the national effort of curing more cancers and saving more lives."

Contents

Foreword

In the UK alone, over 330,000 people are diagnosed with cancer each year. This number is expected to rise to over 425,000 by 2030[1]. Cancer is a disease that touches so many of our lives, and tackling it remains a major healthcare challenge, in the UK and across the world.

The Science and Technology Facilities Council is one of Europe's largest multi-disciplinary research organisations. We support scientists and engineers to undertake world-class research and innovation in the UK and internationally, and we design, build and operate large-scale research facilities for the physical and life sciences. The outcomes of our research are applied to many fields, including healthcare. It is our vision to maximise the impact of our knowledge, skills, facilities and resources for the benefit of the UK and its people, and we believe that applications developed as a result of our work can help fight the battle against cancer.

This cancer strategy sets out how we will harness our key strengths and capabilities to help address three priority areas associated with cancer: diagnosis, radiotherapy and long-term patient follow-up. We will encourage other collaborators to work in partnership with us, stimulate discussions on how to engage better with industry, and develop appropriate delivery mechanisms. This strategy will contribute to the delivery of one of our organisation's strategic themes, to address the key challenges facing our society in the 21st century, as outlined in the *STFC 2010-2020 Corporate Strategy:* "Solutions for Global Challenges".

We are committed to moving our cancer strategy forward, and forging a new path to tackling this widespread and deadly disease.

Professor John Womersley
Chief Executive Officer

Executive summary

The Science and Technology Facilities Council (STFC) is committed to contributing to the national effort of curing more cancers and saving more lives, working with others to maximise the efforts for diagnosis and treatment.

To achieve this, we will focus our efforts in three key areas where there are unmet clinical needs:

1. Diagnosis
2. Radiotherapy
3. Long-term patient follow-up

These three areas were identified to have a significant impact on cancer, through discussions with the cancer and STFC communities over the past four years.

A summary of STFC expertise and technologies applicable to diagnosis, radiotherapy, and long-term patient follow-up can be found in table one.

In a speech to the King's Fund on 13 November 2014, Jeremy Hunt, UK Secretary of State for Health, described how the healthcare system in England is facing perhaps the toughest financial climate in its history, and to face it, our healthcare system needs sustainable solutions for the big challenges ahead; solutions that improve patient care and reduce cost at the same time. He outlined the ways in which technological innovation can unlock personalised medicine and how it can be used to catalyse improvements in preventing diseases.

STFC's wide range of expertise and technologies, at our national laboratories, large-scale facilities, and at the universities we support across the UK, could have a positive impact on cancer if focused to address the above priority areas.

This document is designed to:

- inform the wider community of our intention to focus on the three priority areas and develop adequate delivery mechanisms;
- encourage other collaborators to work in partnership with us; and
- stimulate discussions on how to engage with industry and prepare for the clinical needs of the future.

	STFC technology areas				
	Hardware		Software		Hardware & Software
Cancer area	Accelerators	Detectors	Data collection and analysis	Simulation / Modelling	Large-scale facilities
Diagnosis	- Compact accelerators for generation of radioisotopes - Accelerator targets for generation of radioisotopes	- Reliable, high-sensitivity detectors for GP surgeries - Multispectral detectors - Low-dose, high-resolution detectors for imaging	- Data mining of information from multiple sources for personalised screening - Data mining of information on large number of cancers for GPs - Data mining for imaging	- Predictive models for personalised screening - Detector modelling	- Big data analysis for personalised screening - Confirming new sensor technology - Laser-driven accelerators for diagnostics
Radiotherapy	- Compact accelerators for proton beam radiotherapy	- Fast detectors / electronics for dynamic beam positioning and beam control systems - Fast detectors / electronics for quality assurance and feedback loops - Detectors for in-vivo dosimetry - Low-dose, high-resolution detectors for imaging	- Software tools for organ motion management - Software tools for adaptive radiotherapy - Data mining for imaging	- Modelling of treatment rooms, background, shielding, etc. - Detector modelling	- Big data analysis for personalised medicine - Confirming new sensor technology - Laser-driven accelerators for proton beam radiotherapy
Long-term patient follow-up		- Low-dose detectors for imaging - Reliable, high-sensitivity detectors for GP surgeries	- Software tools for recording of late side-effects - Data mining of follow-up information		

Table one: Summary of STFC expertise and technologies applicable to diagnosis, radiotherapy, and long-term patient follow-up

This table is colour-coded to denote the level of overlap with STFC's capabilities and existing activities.

Key

strong overlap (pink) | medium overlap (yellow) | some overlap (white)

In the UK over 330,000 people are diagnosed with cancer and around 162,000 die from the disease every year.

An ageing population, the rise in obesity levels and changes in lifestyle mean that by 2030, the number of people diagnosed with cancer in the UK is predicted to rise to more than 425,000 new cases being diagnosed annually[2].

Through research and scientific advances over the last 40 years, cancer survival rates in the UK have doubled, from just a quarter of people surviving in the 1970s to half of those diagnosed surviving today.

Despite these improvements in survival and mortality rates, cancer outcomes in the UK remain poor when compared with the best outcomes in other countries in Europe and around the world.

As well as having a devastating human impact, cancer also has significant financial consequences on the National Health Service (NHS) and the wider economy. The annual NHS costs for cancer services are £5 billion, but the cost to society as a whole, including costs for loss of productivity, is £18.3 billion[3]. These costs are set to rise even further as cancer incidence increases, people live for longer with cancer and new treatments become available.

The UK has a long history of research into cancer. Over the years, the number of organisations funding research into cancer has grown and the level of research activities has consequently risen. Cancer strategies have been published by the Department of Health in 2007[4] and 2011[5] . Cancer Research UK (CRUK) has published its latest research strategy 'Beating Cancer Sooner' in 2014[1].

A societal imperative for the future is to provide improved health, wellbeing, patient care and quality of life, and to ensure delivery of high-quality healthcare in increasing volume but at decreasing cost[6].

The UK Government sees the development of healthcare technology as one of the key platforms on which to do this, and build economic recovery. The exploitation of high technology resources is vital to this agenda, as well as to the plan of delivering large volume, high-quality healthcare at reduced costs.

STFC and its scientific community continue to develop new, advanced technologies that could have a positive impact on cancer if focused on specific areas. This challenge-led strategy shows how, when focused on key areas, our collective expertise, high-performance technology and large-scale facilities could move us closer to more effective cancer care.

Introduction

Our large-scale facilities have a track record of undertaking work to understand the biological processes that cause cancer and develop new drugs[7]. These capabilities are not covered by this strategy, which instead focuses on the unique technological contributions we can make to the cancer challenge.

This strategy for cancer was developed following extensive consultation with and input from the cancer community, STFC staff and the wider scientific community funded by STFC. Within the cancer community, discussions took place with senior members of the Department of Health (DH) and NHS England, including two National Clinical Directors, the National Cancer Research Institute (NCRI), Cancer Research UK (CRUK), the British Institute of Radiology (BIR), the British Nuclear Medicine Society (BNMS), the Institute of Physics and Engineering in Medicine (IPEM) and the Society and College of Radiographers (SCoR), including various presidents of professional bodies and healthcare professionals. In parallel, a series of visits to STFC-funded university groups was carried out and a Cancer Care Forum for STFC staff was created. This allowed us to map the key strengths and capabilities that STFC has to offer to address the cancer challenge. The STFC capabilities relevant to cancer that were identified as part of this process were further explored in a series of three workshops organised by STFC jointly with the BIR, IPEM and DH, which also served to establish closer links between the two communities.

Technology to detect cancer at the bedside

Using Challenge Led Applied Systems Programme (CLASP) investment, researchers at the University of Leicester have adapted gamma-ray technology originally used for astronomy in order to improve the detection and treatment of cancer. In collaboration with researchers at the University of Nottingham, the Leicester scientists developed a hybrid gamma-optical camera and went on to form a spin-out company, Gamma Technologies Ltd. The portable, high-resolution camera extends the use of nuclear medicine procedures to the bedside and operating theatre; it also reduces the cost of detecting and treating cancer. The device is currently undergoing trials at Queen's Medical Centre, Nottingham.

For more information, visit: http://www.stfc.ac.uk/files/nuviews-combined-optical-and-gamma-camera-system/

Our vision for cancer

STFC's vision for cancer is to contribute to the national effort of curing more cancers and saving more lives. Our aim is to focus our efforts on improvements in three key areas where there are unmet clinical needs, as identified by the cancer community:

1. **Diagnosis**
2. **Radiotherapy**
3. **Long-term patient follow-up**

We also aim to provide UK Government and healthcare organisations with advanced technology for these three areas.

To achieve our aim, we are looking for other organisations to establish new collaborations and work in partnership.

We also want to engage more closely with industry and work with our community to further develop existing delivery mechanisms, as well as identify new ones if needed, and with the cancer community to prepare for the clinical needs of the future.

Technology for particle physics improves medical imaging

'Rutherford Cable', a type of superconducting cable that was invented at STFC's Rutherford Appleton Laboratory for particle physics applications, has underpinned the development of magnetic resonance imaging (MRI) scanners. Without this research, today's high-resolution MRI scanners would not have been possible. In England each year, 2.3 million life-saving MRI examinations are performed, and the industry is worth £111m to UK gross domestic product (GDP).

For more information, visit: http://www.stfc.ac.uk/about-us/our-impacts-achievements/case-studies/technology-for-research-saves-lives/

A step closer to earlier cancer diagnosis

Research funded by the Engineering and Physical Sciences Research Council (EPSRC) (£3.2 million) led by the University of Liverpool and involving NHS trusts, will use a state-of-the-art tissue culture centre at STFC's ALICE accelerator to understand the effects of terahertz radiation on human cells. The aim is to significantly improve the diagnosis and treatment of three most common forms of cancer: prostate, cervical and oesophageal.

Oesophageal cancer has the fastest rise in incidence in the western world, affecting more than half a million people annually world-wide. Prostate cancer affects 10% of males in developed countries, with 30,000 new cases annually in the UK alone. These cancers can be treated much more successfully if diagnosed early and this project aims to develop a new generation of portable, accurate low-cost instruments for improve cancer diagnosis.

Professor Erika Denton, National Clinical Director for Diagnostics and Imaging, NHS England, said: "This collaboration has the potential to bring significant improvements in patient care and is an excellent example of the kind of world leading, multidisciplinary research we excel in undertaking in the UK and especially at STFC."

For more information, visit: http://www.stfc.ac.uk/news/future-of-cancer-diagnosis-looking-much-brighter-thanks-to-work-of-uk-researchers/

Small particle accelerators and cancer treatment

STFC's Hartree Centre has provided Tech-X Corporation with access to its high performance computing (HPC) facilities, to accurately simulate novel next-generation accelerator prototypes. Novel, smaller accelerator technologies would have the potential to revolutionise areas such as cancer treatment, so finding a way to make existing technologies smaller is a high priority. The ability to rapidly prototype experimental designs for these novel accelerator technologies relies heavily on accurate accelerator beams simulations, which cannot be achieved without international class, high-resolution computation such as that of the Hartree Centre.

For more information, visit: http://www.stfc.ac.uk/about-us/our-impacts-achievements/smaller-affordable-particle-accelerators-for-healthcare-and-security/

Strategic framework

Our vision for cancer

To contribute to the national effort of curing more cancers and saving more lives

Our objectives

- Diagnosis
- Radiotherapy
- Long-term patient follow-up

Our approach

- Focus our technologies and capabilities
- Develop partnerships
- Develop our delivery mechanisms
- Engage with industry
- Prepare for the clinical needs of the future

Our objectives

Diagnosis

To reduce cancer mortality and increase survival, it is vital to ensure cancer is diagnosed at an early stage, to avoid the disease spreading throughout the body and developing metastases.

Screening

Screening plays an important role in the prevention and diagnosis of cancer. There are currently three cancer screening programmes operating in England: bowel, cervical and breast. The aim of bowel and cervical screening is to prevent cancer by detecting premalignant lesions, while the aim of the breast screening is to detect already-developed cancer.

It is not possible to estimate how many cancers are prevented through screening: in the case of cervical cancer, this figure has been estimated at 80%, but this may be an overestimate. Between 1 April 2012 and 31 March 2013, 19,339 breast cancers were detected by screening in the UK[8].

Screening programmes for other cancers may be introduced in the future.

Early diagnosis

In England, late diagnosis is a major reason for poor survival rates. Currently, a large number of patients present when the cancer is in an advanced stage, and nearly a quarter of them are diagnosed via emergency routes. If the disease could be diagnosed and treated at an earlier stage, the chances of survival would increase significantly for almost all patients. In fact, if the number of cancers diagnosed at an earlier stage (stages I or II) could be increased by 1%, around 1,200 more patients would be alive five years after diagnosis[1].

Diagnostic imaging[9]

Over the last 10 years, the overall number of diagnostic imaging procedures has gone up by 40%, representing an average growth of 3.4% per year. The total number of imaging examinations or tests carried out in the UK from 1st April 2013 to 31st March 2014 was 42.9 million. Of these 42.9 million, 23.1 million were X-Rays (radiographs), 10.0 million were ultrasound, 5.2 million were computed tomography, 2.7 million were magnetic resonance imaging, 1.3 million were fluoroscopy, and 0.6 million were radioisotope-based. These numbers are predicted to continue growing in the coming years, due to an expanding and ageing population. Currently, over 80% of clinical nuclear medicine procedures are based on Tc-99m (Technetium-99m, symbolised as Tc-99m, is a metastable nuclear isomer of Technetium-99). This is not expected to change in the near future. It is, however, difficult to predict the increase in Tc-99m demand in the coming years, as this is strongly dependent on diverse factors relating to its production. The use of imaging procedures based on other radioisotopes and in particular positron emission tomography (PET) is also expanding.

Technology needs

The cancer community highlighted the need for new advanced technology in the areas of screening, early diagnosis and diagnostic imaging. The three tables below show examples of the hardware and software technologies needed in all three areas, along with STFC technologies applicable to those areas.

Table two: Technology needed to aid cancer screening

Screening		
	Technologies needed	STFC technologies
Hardware	– Techniques and processes that are cost-effective, easily available and provide high specificity and fast results	– Multispectral detectors – Confirming new sensor technology
Software	– Predictive models for smart screening – Software for integrating other information, such genetics, for personalised screening	– Predictive models for personalised screening – Big data analysis for personalised screening – Data mining of information from multiple sources for personalised screening – Detector modelling

'No needles' breast cancer diagnosis technique on the horizon

A technique being developed at STFC's Central Laser Facility for improving breast cancer diagnosis, could remove the need for needle biopsies. Two million mammograms are carried out annually in the UK. Suspect scans are recalled and can only be diagnosed through a needle biopsy, with around 80% of biopsies being negative. A grant awarded by EPSRC to Exeter University and STFC in partnership with the Gloucestershire Hospitals NHS Foundation Trust will allow testing this technique on human breast tissue ex vivo and could lead to the biopsy being replaced by non-invasive screening with instantaneous results. This technique, which should be available within the next decade, could save the NHS £10-20 million per annum, avoid unnecessary anxiety for patients and in case of positive diagnosis, allow treatment to start earlier.

For more information, visit: http://www.stfc.ac.uk/research/medicine-health-biological-sciences/faster-breast-cancer-screening-on-the-horizon/

Table three: Technology needed to aid early diagnosis of cancer

Early diagnosis		
	Technologies needed	STFC technologies
Hardware	– Low-cost, reliable, possibly low-tech, ideally high-resolution, low or no radiation techniques for GP surgeries – Suitable technology for collecting multiple inputs from various tests – Technologies to be used at home	– Reliable, high-sensitivity detectors for GP surgeries – Multispectral detectors – Confirming new sensor technology
Software	– Software for data collection – Software for data sharing between GPs and GP surgeries, and between GPs and hospitals in a way that protects patient privacy – Bioinformatics and computer techniques for risk stratification and for risk analysis – Intelligent decision support systems – Filtering algorithms to be provided to patients – Software systems to gather information from a large number of cancer cases	– Data mining of information on large number of cancers for GPs – Detector modelling

Table four: Technology needed to aid diagnostic imaging

Diagnostic imaging		
	Technologies needed	STFC technologies
Hardware	– Low-cost, smaller and efficient imaging technology with increased reproducibility, sensitivity, resolution, temporal stability and image quality, offering better soft tissue contrast and detectors with optimised resolution for particular tracers – Low or no-dose imaging technologies, such as optical imaging and high-precision microscopic imaging – Technology for easier interpretation of data, for dealing with artefacts and for advanced multi-parametric imaging – Alternative ways of producing radioisotopes and in particular Tc-99m – New quality assurance / quality control systems	– Low-dose, high-resolution detectors for imaging – Confirming new sensor technology – Compact accelerators for generation of radioisotopes – Laser-driven accelerators for diagnostics
Software	– Data warehouses and databases for storing, sharing and mining imaging data and software infrastructure with greater computing power to handle a large amount of processing – Software to collect and share data in a secure, easy and properly anonymised way – Software, including data mining techniques and offline processing, for the analysis of data, also of large sets, which provides improved characterisation of the disease and for image reconstruction, registration, and validation – Software for multi-modality imaging – Medical informatics and software to integrate imaging data with other types of data – New or increased standardisation for imaging techniques and of imaging processing and data formats	– Data mining for imaging – Detector modelling

Radiotherapy

Ensuring that all cancer patients receive the appropriate treatment, delivered to a high standard, is critical to improving cancer outcomes. Radiotherapy has an important role in the treatment of cancer, being second only to surgery, the most effective cure. Of all the patients who are cured, 40% will have received radiotherapy, while 49% of them will have had surgical intervention[1]. While for some cancers radiotherapy may be the main form of treatment, for others it may be used alongside surgery or chemotherapy. Radiotherapy is also extensively used to alleviate symptoms of advanced cancers. It is estimated that at least half of all cancer patients require radiotherapy at some point in their care pathway.

X-ray radiotherapy

Additional high-quality, advanced X-ray radiotherapy equipment will be required around the country to ensure all patients that would benefit from radiotherapy[10] have access to it, and to cope with the 2-3% increase per year in demand for such treatments, caused by the aging population. To improve outcomes, the new radiotherapy services will not only focus around the patients' needs, but they will also target the cancer more accurately, whilst causing fewer side-effects.

Proton beam and other forms of advanced radiotherapy

Improved outcomes can also be delivered by ensuring that patients have access to high-quality, modern radiotherapy that will improve cure rates and minimise long-term side-effects of treatment. We need to employ techniques comparable to those used in other countries, but which are not yet available in the UK. One example of high-quality, modern radiotherapy is proton beam radiotherapy. This is a very precise form of radiotherapy that can be effective in treating a number of cancers, avoiding damage to critical tissues near the tumour. In the UK, proton beam radiotherapy is currently available at the Clatterbridge centre, and only for eye tumours. Two new NHS centres are due to open in 2017-18 at University College London Hospital in London and the Christie Hospital in Manchester and are designed to treat, combined, up to 1,500 patients a year[3].

Imaging for radiotherapy

Imaging is essential at various stages of radiotherapy: from planning treatment, to monitoring tumour response during treatment and assessing the response to treatment. Advanced medical imaging, including molecular and functional imaging, is crucial to deliver improvements in all forms of radiotherapy. This helps to improve treatment outcomes by targeting the cancer more accurately, through tightly defining the margins of the volume to be treated. It also allows more precise treatments to be tailored to the individual.

Technology needs

The cancer community highlighted the need for new advanced technology in the areas of: X-ray radiotherapy, proton beam and other forms of advanced radiotherapy, and imaging for radiotherapy. The three tables below show examples of the hardware and software technologies needed in all three areas, along with STFC technologies applicable to those areas.

Table five: Technology needed to aid X-ray radiotherapy

X-ray radiotherapy		
	Technologies needed	**STFC technologies**
Hardware	– Low-cost, smaller and true real-time hardware – Next-generation compact and cost-effective delivery systems that could also provide dose painting – New quality assurance / quality control systems and faster feedback-led quality assurance systems, requiring less frequency – New technologies for dosimetry	– Fast detectors / electronics for dynamic beam positioning and beam control systems – Fast detectors / electronics for quality assurance and feedback loops – Detectors for in-vivo dosimetry – Confirming new sensor technology
Software	– Software for integrating various information for personalised medicine – New software structure and infrastructure, such as data warehouses, for a more extensive use of Grid computing – Software for data collection, sharing in a secure, easy and anonymised way and analysis and advanced computing for patient referral capable of dealing with very large amount of data – True real-time software tools – Software for treatment planning, motion management, to quantify the dose delivered during treatment, to monitor changes and to monitor and evaluate the response to treatment – New models and modelling tools such as new radiobiological models and new micro-dosimetry models	– Big data analysis for personalised medicine – Software tools for organ motion management – Software tools for adaptive radiotherapy

Table six: Technology needed to aid proton beam and other forms of radiotherapy

Proton beam and other forms of radiotherapy		
	Technologies needed	STFC technologies
Hardware	– Structures with less concrete and less steel to reduce beam losses – Accelerators that are small, compact, low-cost, 100% reliable and not requiring any backup – Beam delivery systems and gantries that are reduced in size and costs – New superconducting magnets – New hardware solutions to increase the throughput, including fast beam control systems, real-time beam splitting and / or multiplexing systems, ways to speed up intensity modulated proton therapy (IMPT) and faster techniques for the spot scanning of larger volumes – New solutions for providing variable beam energy, including beams of higher energy for exit imaging – New direct and indirect methods and higher efficiency detector materials for in-vivo range verification – New technologies for dosimetry and neutron detectors – New technology for ion radiotherapy such as new delivery systems based on compact accelerators	– Compact accelerators for proton beam radiotherapy – Laser-driven accelerators for proton beam radiotherapy – Fast detectors / electronics for dynamic beam positioning and beam control systems – Fast detectors / electronics for quality assurance and feedback loops – Detectors for in-vivo dosimetry – Confirming new sensor technology
Software	– Software for integrating various information for personalised medicine – New software structure and infrastructure, such as data warehouses, for a more extensive use of Grid computing – Software for data collection, sharing in a secure, easy and anonymised way and analysis and advanced computing for patient referral capable of dealing with very large amount of data – True real-time software tools – New systems for proton beam radiotherapy treatment planning and software for treatment planning, motion management, to quantify the dose delivered during treatment, to monitor changes and evaluate the response to treatment and advanced data processing for in-vivo range verification – New effective online verification systems and methods also for the more complex beam configurations – New robust tools to assess proton beam radiotherapy treatments against X-ray radiotherapy treatments – New simulations, transport code and modelling, such as new radiobiological models and new models for micro-dosimetry, dose accumulation and for neutrons	– Big data analysis for personalised medicine – Software tools for organ motion management – Software tools for adaptive radiotherapy – Modelling of treatment rooms, background, shielding, etc.

Table seven: Technology needed to aid imaging for radiotherapy

Imaging for radiotherapy		
	Technologies needed	STFC technologies
Hardware	– Low-cost, cost-effective and efficient imaging techniques for cellular imaging and fast, real-time, in-room imaging technology for treatment planning and verification, organ motion management, dose quantification, to monitor changes and to monitor and evaluate the response to treatment – New imaging supporting technologies for tracking organ motion, such as technologies for tracking the patient breathing – In-room, real-time, ideally either dose-free or low-dose, 4D imaging technology for proton beam radiotherapy also capable of providing information on the beams, such as proton radiography and prompt gamma detection techniques; new imaging detectors for proton radiography	– Low-dose, high-resolution detectors for imaging
Software	– Software for integrating various information for personalised medicine – Data warehouses and databases for storing, sharing and mining imaging data and software infrastructure with greater computing power to handle large amount of processing – Software to collect and share data in a secure, easy and properly anonymised way – Software for image reconstruction, registration and validation, for the scanning, defining the volume and segmentation of the target, for real-time imaging, including real-time organ motion management and compensation techniques, and for handling when the patient has moved between images – Software for multi-modality imaging – Real-time computational modelling and new models, such as for doses in imaging procedures and associated toxicity	– Big data analysis for personalised medicine – Data mining for imaging – Detector modelling

Long-term patient follow-up

Survival rates for cancer are improving, with ten-year survival rates having doubled in the last 30 years and continuing to increase. The total number of people living longer with and beyond cancer is therefore growing considerably. As more patients become long-term survivors of cancer, they should be provided with the assistance they need to resume as normal a life as they can and to reduce ill-health associated with cancer treatment. Patient follow-up at the end of the treatment is undertaken with several objectives, including the detection and management of acute complications or side-effects of treatment, early clinical detection of recurrence, and detection of late effects of treatment, such secondary cancers induced by treatment.

Patient follow-up in primary care

Currently, 1.8 million people are living with cancer in England. This is expected to rise to over three million by 2030[5]. To meet increasing demands in a way that is affordable for the NHS, follow-up procedures will have to change: patient follow-up would be best moved away from secondary care and into primary care wherever possible. This will require the development of technologies suitable for use in GP surgeries.

Patient follow-up in secondary care

Current follow-up arrangements usually involve outpatient appointments at hospitals and cancer centres. Improvements could be made and new technologies introduced, to better meet the needs people may have following cancer treatment. It may also be possible to make changes to existing patient follow-up systems, so that they will provide better value for money for the NHS.

Patient follow-up after radiotherapy

Treatment-related malignancies are a risk in patients who have had radiotherapy. As the life expectancy of patients is increasing after treatment, they will need to be followed up for longer, to ensure this risk is managed.

Technology needs

The cancer community highlighted that the need for new advanced technology in the area of patient follow-up after radiotherapy were the same as the ones in the areas of patient follow-up in primary and secondary care. The two tables below shows examples of the hardware and software technologies needed in two different areas of long-term patient follow-up, along with STFC technologies applicable to these areas.

New scanner could revolutionise breast cancer screens

Using Global Challenge funding, researchers from University of Surrey, University of Manchester and STFC have shown that the STFC's HEXITEC state-of-the-art imaging technology could be combined with new advances in X-ray source technology, to develop a new type of breast computed tomography (CT) scanner. This dedicated CT scanner could replace planar X-ray mammography, which is the current gold standard screening method for breast cancer. Breast CT would not only avoid breast compression, which can be painful and lead to procedure refusals, but would also remove the distracting background always present in a conventional mammogram. Images without background would be easier to interpret by the radiologist, making the detection of cancer easier and reducing the probability of false detections, which is a major problem with current screening technology.

For more information, visit: http://gtr.rcuk.ac.uk/project/8F5C9FA7-3A9A-4DFD-9212-C27964AFA9EE

Table eight: Technology needed to aid long-term patient follow-up in primary care and radiotherapy

Follow-up in primary care and radiotherapy		
	Technologies needed	STFC technologies
Hardware	– Automated surveillance systems and technologies for the patient use, such as mobile phones – Low-cost and reliable techniques for GP surgeries	– Reliable, high-sensitivity detectors for GP surgeries
Software	– Systems for linking data from different GP surgeries	– Data mining of follow-up information

Table nine: Technology needed to aid long-term patient follow-up in secondary care and radiotherapy

Follow-up in secondary care and radiotheraphy		
	Technologies needed	STFC technologies
Hardware	– High throughput, cost-effective, more efficient follow-up hospital technology that is safer for the patient, such as reduced-dose or zero-dose imaging	– Low-dose detectors for imaging
Software	– Software tools for better recording of late effects – Systems for linking data from primary care, hospital-based care and cancer registries that automatically capture follow-up information with minimal inconvenience to patients	– Software tools for recording of late side-effects – Data mining of follow-up information

Our approach

Delivering the strategy

To achieve our objectives, STFC will take the following five actions:

1. Focus our technologies and capabilities
2. Develop partnerships
3. Develop our delivery mechanisms
4. Engage with industry
5. Prepare for the clinical needs of the future

These will be further developed and updated and a detailed implementation plan produced in consultation with both the cancer and our communities as the strategy is taken forward.

Action 1: Focus our technologies and capabilities

To achieve its vision and have an impact in cancer, STFC wishes to focus its efforts in diagnosis, radiotherapy and long-term patient follow-up. Our community at the STFC national laboratories, large-scale facilities, and universities across the UK, is already involved in many activities related to cancer. This strategy will therefore serve as a guide to inform them, helping to focus their many technologies in the three key areas.

Action 2: Develop partnerships

STFC will actively seek to develop more partnerships to achieve its vision and to help address the cancer challenge through multidisciplinary interactions, collaborations and networks. By working in partnership with other organisations that are funding research into cancer, we will contribute to maximise the national effort for better diagnosis and treatment.

New multidisciplinary collaborations that cut across the cancer community and our community, and new cross-disciplinary cancer-STFC teams will allow better communication between them. This will help ensure that unmet clinical needs are addressed. We are currently forming a network in advanced radiotherapy that may provide a model for how to connect research groups across different disciplines.

Action 3: Develop our delivery mechanisms

STFC will review the delivery mechanisms that are needed for the strategy. In consultation with the community, we will adapt existing mechanisms and explore their further development if appropriate. We will also consider creating new delivery mechanisms, if the existing ones are not appropriate to the delivery of the strategy. Examples of delivery mechanisms already in place and that may be developed further are the Global Challenge Programme[11] and the Challenge Led Applied Systems Programme (CLASP)[12], to support the application of STFC research in key global challenge areas, including healthcare.

Action 4: Engage with industry

STFC understands the critical things industry needs to pull innovation through to market. Through a closer engagement with industry, we want to help make new technologies commercially available and adopted by the NHS. On the industry side, we will seek to work more closely with Innovate UK and the Knowledge Transfer Networks (KTNs) as well as companies that are located on the Harwell and Daresbury Campuses, such as the Electrospinning Company[13] and Bio-AMD[14], and large healthcare businesses like GE, Philips and Siemens. On the NHS side, we will seek to engage directly with Academic Health Science Networks, one of which[15] is located on the Daresbury Campus, NHS Regional Innovation hubs, one of which[16] is located on the Harwell Campus and the National Institute for Health Research (NIHR). We will also explore interactions with the new translational medicine centres being created, such as the Institute of Translational Medicine in Birmingham.

Action 5: Prepare for the clinical needs of the future

STFC knows that new unmet clinical needs and priorities requiring advanced technological solution are likely to appear in the future. We also recognise that the development of appropriate cost-effective technology is a long-term challenge and may not be quickly stepped-up. We will continue to engage with the cancer community in the UK and the various stakeholders to ensure that they are kept informed and involved in the strategy. This will keep us abreast of emerging directions in cancer diagnosis and treatment and maintain our visibility. We will also explore the possibility of monitoring, through our international connections, developments in cancer needs around the world and how to link them back to the UK if desired.

Astrophysics software helps children undergo medical imaging

Scientists from Edinburgh University took an algorithm originally developed for astrophysics and generalised it to any problem where large sets of data must be analysed quickly. The spin-out Blackford Analysis was formed in 2010 to develop commercial solutions based on this generalised algorithm. The company offers services directed at rapid registration of massive imaging datasets, with applications in the medical, defence and energy sectors. For example, a modified version of the algorithm has been used to stabilise magnetic resonance images of moving patients, allowing young children to be scanned without anaesthetic.

For more information, visit: http://www.stfc.ac.uk/files/blackford-analysis-from-stars-to-spinout/


Appendixes
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Appendix A – Stakeholders

The following organisations have been identified as stakeholders of this strategy.

A.1 Government departments and agencies

1. Department of Health (DH)
2. The National Health Service (NHS)

A.2 Funders

1. Biotechnology and Biological Sciences Research Council (BBSRC)
2. Cancer Research UK (CRUK)
3. Engineering and Physical Sciences Research Council (EPSRC)
4. Medical Research Council (MRC)

A.3 Professional bodies

1. The British Institute of Radiology (BIR)
2. The British Nuclear Medicine Society (BNMS)
3. The Institute of Physics and Engineering in Medicine (IPEM)
4. The Society and College of Radiographers (SCoR)

A.4 Other organisations

1. The National Cancer Research Institute (NCRI)

Appendix B – Glossary of terms

BBSRC	Biotechnology and Biological Sciences Research Council
BIR	British Institute of Radiology
BNMS	British Nuclear Medicine Society
CLASP	Challenge Led Applied Systems Programme
CRUK	Cancer Research UK
CT	Computed Tomography
DH	Department of Health
EPSRC	Engineering and Physical Sciences Research Council
HPC	High Performance Computing
IMPT	Intensity Modulated Proton Therapy
IPEM	Institute of Physics and Engineering in Medicine
KTN	Knowledge Transfer Network
MRC	Medical Research Council
MRI	Magnetic Resonance Imaging
NCRI	National Cancer Research Institute
NIHR	National Institute for Health Research
NHS	National Health Service
PET	Positron Emission Tomography
SCoR	Society and College of Radiographers
STFC	Science and Technology Facilities Council

Appendix C – References

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3 Department of Health; Ellison, Jane (MP), Helping more people survive cancer: http://www.gov.uk/government/policies/helping-more-people-survive-cancer

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5 Department of Health, Improving Outcomes: A Strategy for Cancer, January 2011: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213785/dh_123394.pdf

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7 See for example: http://www.stfc.ac.uk/clf/34713.aspx and http://www.stfc.ac.uk/research/new-nanomaterial-offers-better-detection-and-treatment-of-breast-cancer/

8 NHS Breast Screening Programme and Association of Breast Surgery, An Audit of Screen Detected Breast Cancers for the Year of Screening April 2012 to March 2013, Public Health England and Association of Breast Surgery

9 The numbers in the paragraph refer to all diagnostic imaging procedures for the different diseases and not only cancer and are taken from: http://www.england.nhs.uk/statistics/wp-content/uploads/sites/2/2013/04/KH12-release-2013-14.pdf

10 Currently access to X-ray radiotherapy is on average less than 40% of all cancer patients, while evidence suggests that 50% of all cancer patients would benefit from the treatment.

11 STFC, Global Challenge Schemes: http://www.stfc.ac.uk/funding/global-challenge-schemes/

12 STFC, Challenge Led Applied Systems Programme: http://www.stfc.ac.uk/funding/working-with-industry/challenge-led-applied-systems-programme/

13 The Electrospinning Company: http://www.electrospinning.co.uk

14 BIO-AMD: http://www.bioamd.com

15 The North West Coast Academic Health Science Network: http://www.nwcahsn.nhs.uk/index.php

16 NHS Innovations South East: http://www.innovationssoutheast.nhs.uk

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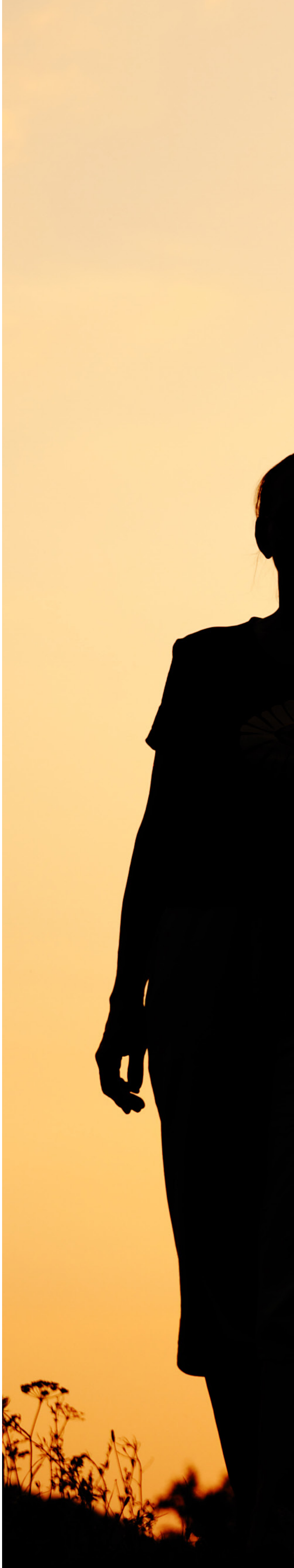


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