Position Statement

The Impact of Extended Clinical Hours on a Radiotherapy Physics Service

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The Institute of Physics and Engineering in Medicine

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1. Executive Summary

All patients should expect to receive a high standard of modern treatment during the delivery of the prescribed course of radiotherapy. The standard of radiotherapy treatment received by the patient should be independent of the time or day they attend for treatment. Delays or cancellations of individual treatment fractions should be minimised.

A high standard of treatment requires appropriate imaging and treatment planning.

- Competent staff across a range of specialties are necessary to prepare and validate the individualised treatment plan.

- Technical and scientific aspects of treatment planning and validation are the responsibility of the scientific and technical staff.

- For complex radiotherapy planning cases all staff groups are required to be present for multi-disciplinary meetings.

- Adequate staff numbers are essential to complete safety critical tasks in a timely manner. It is important that Medical Physics Expert support is available to support the treatment and treatment planning processes.

To avoid delays to the start of a course of radiotherapy and cancellations of individual treatment fractions a safe and resilient treatment and planning environment must be in place.

- A safe resilient infrastructure requires all imaging and therapy equipment to function within predetermined geometric and radiation tolerances for safe radiotherapy planning and delivery.

- The integrity of software applications must be demonstrable and all the data transfer links robust and proven.

- This is ensured with programmes of planned maintenance, corrective maintenance and quality assurance.

- In a survey of UK Radiotherapy Centres undertaken in January 2014, the time required for maintaining a safe infrastructure in an average size radiotherapy centre (5.1 linacs) was reported to be 1250 hours per annum, excluding daily quality assurance.

Patients should receive radiotherapy using up to date equipment and software.

- To ensure a modern infrastructure, regular up-grades to radiotherapy equipment and software are necessary.
• These upgrades require time to implement and ensure correct operation for a safe service.

• On average a further 1500 hours per annum would be required to maintain a modern and up to date infrastructure.

Patients should receive a high standard of radiotherapy using modern treatment techniques.

• The extensive use of advanced technology has impacted positively on the quality of the treatment delivered to patients. However these techniques require access to the linacs to undertake patient specific Quality Assurance. For an average size centre this requires a further 200 hours of access per annum to the linacs.

• To develop and maintain a modern state of the art radiotherapy service access to the planning and treatment equipment is required for service development, clinical trials and research and development. Staff are required to progress developments in addition to delivering the clinical service.

Delays and cancellations of treatment fractions should be minimised.

• The total time required to maintain and develop a safe and modern radiotherapy service equates to one linac year of activity in an average department. Any plan to extend the clinical hours in a radiotherapy centre needs to identify when this time will be scheduled.

• One option could be the use of a Service Efficiency Machine, as outlined in the NRAG report published in 2007. Alternatively week end, evening or night working could be considered.

• Manufacturers have stated that they do not currently have the infrastructure in place to support significant extended hours working with service desk support and out of hours maintenance. The manufacturers would seek a national commitment to provide extended hours service cover. A lead-in time of approximately 2 – 3 years would be required for the manufacturers to recruit and train the necessary personnel. An increase in the cost of maintenance in the order of 70% could be anticipated to deliver such a service.

• Trusts should ensure there are sufficient trained local engineers to work with manufacturer’s engineers and provide first line support in the event of unplanned maintenance.

• Trusts should ensure that IT departments provide adequate facilities to enable manufacturers to make full use of modern IT technology during maintenance and repair.

• When modelling increased access to radiotherapy, consideration could be given to providing additional linac capacity in addition to that required for the planned clinical service. This additional capacity would allow the infrastructure maintenance and service development to be completed during the working week. This may prove to
be a more economically viable solution in the long term when manufacturers’ costs are taken into consideration.

Possible models for extended clinical hours:

- Three models of extended clinical hours of service have been considered in this report:
  - Extended hours week day clinical service, which would enable the option of infrastructure support work, such as software upgrades, to be undertaken at the week end provided there are adequate staffing levels for safe working practices.
  - A six day clinical service where some infrastructure support could be completed on a Sunday but for extended periods of servicing would require access on either a Saturday or Monday.
  - Seven day clinical working where all infrastructure support work would be scheduled during the clinical working week.

- Any model for an extended hours clinical service should be risk assessed locally to ensure safe delivery with no comprise to the outcome of treatment in the event of equipment failure or resolution of problems with individual treatment delivery.

- The range of staff present in a centre during the hours of clinical treatment delivery is dependent on the percentage of equipment available for and in clinical use, and the clinical service being delivered.

- Extending the clinical working hours and/or increasing the activity of a centre will require an increase in personnel at all grades and adequate numbers of Medical Physics Experts are important to ensure a safe radiotherapy service. This requires adequate commissioning of training places at all levels.

- Taking account of the factors discussed in this report it is recommended that extended hours week day working or seven day working would be the preferred options.
2. Introduction

2.1 The Development of ‘Extended Hours’ Clinical Services

A seminal document for Radiotherapy Services in England was the Report ‘Radiotherapy: developing a world class service for England’ [1] published by the National Radiotherapy Advisory Group (NRAG) in February 2007. It described the service at that time and detailed a number of recommendations for improvement. The Executive Summary included the following recommendations:

‘9.iii. radiotherapy departments operate 239 days per year – a standard 5 day week, closing for only 3 bank holidays and ensuring that each linac is out of action during normal working hours for no more than 19 days for QA/servicing a year. In addition, departments undertake some palliative radiotherapy on Saturdays. [Availability of staff and the appropriate skills mix will be the rate limiting factor for many localities seeking to increase productivity in this way.]

9. iv. radiotherapy departments have a service efficiency machine i.e. an additional machine that would be in use 50-75% of the time providing capacity to deal, for example, with unexpected peaks in workload or linac breakdown without increasing waiting times for patients and minimising the need for cancellations/ rescheduling. ’

At that time there was an assumption that the majority of the clinical service would be delivered over a 5 day week and that maintenance and quality assurance (QA) would take place during the clinical week. It was recognised that some QA took place during weekday evenings which was not accounted for in the 19 days stated as necessary.

In order to increase radiotherapy capacity the report included the recommendation that ‘linacs within radiotherapy departments work on average 9.2 hours per day with a minority running for an extended day (e.g. 11.5 hours)’

Whilst it was acknowledged that some palliative radiotherapy might be undertaken on a Saturday there was no stated intention to significantly increase the length of the working week.

Furthermore there was a recommendation that ‘in addition to having a service efficiency machine, radiotherapy departments progressively increase capacity so that they operate at 87% capacity i.e. they are capable of delivering 13% more activity than is actually required (10% to allow for variations in demand; 3% to allow for testing techniques & staff training).’

Thus testing and developing new techniques and staff training were considered to be important elements of the clinical working day.

Following the NRAG Report, the National Clinical Analysis Specialised Applications Team (NATCAN SAT) established from April 2009 the collection of the Radiotherapy Dataset, which records and reports clinical activity at each radiotherapy centre on a national basis. However, to date, the time required for non-patient activity, which is necessary to maintain
and develop a world class radiotherapy service, has not been collected, published or accounted for, in the clinical activity of a department.

In 2011 a report from the National Audit office 'Managing high value capital equipment in the NHS in England' [2] included the following significant statement;

‘For radiotherapy, a 2007 report by the National Radiotherapy Advisory Group recommended extended hours for some units, but there is uncertainty about the willingness of patients to attend for treatment outside traditional opening times’.

This document highlighted the issues around the need to establish a replacement programme for ‘Big Ticket Items’ of equipment such as linear accelerators, and it also included a review of the clinical hours of use of such items of equipment.

It concluded by stating that 'We found examples of how trusts had evaluated the configuration of their services and have taken steps to improve their efficiency of machine use, by:

- achieving the right skill mix to support throughput;
- assessing the flexibility of working patterns and opening hours;
- strong engagement between finance and clinical teams;
- using the right data to measure performance; and
- assessing design and flow to support the patient pathway.’

This report contributed to a prompt to the radiotherapy community to develop and undertake a Radiotherapy Patient Access Survey which was carried out over the summer of 2012, with the results first presented at the National Radiotherapy Implementation Group (NRIG) conference in November 2012. The survey concluded that patients would be willing to attend for radiotherapy outside the previously accepted clinical hours of 09.00hrs and 18.00hrs, at weekends and Bank Holidays. Extending the hours of the clinical service was also seen to improve patient choice.

With the recent increase in delivery of advanced radiotherapy techniques following the government’s Radiotherapy Innovation Fund in early 2013, the requirement for patient-specific QA and hence associated non-clinical time on a linear accelerator has increased dramatically.

In parallel with these initiatives many radiotherapy centres have been extending their hours of clinical service often for limited periods of time to accommodate the clinical activity required to avoid breaches of the Cancer Waiting Time targets, manage high levels of clinical demand and to minimise delays in patients’ treatment as recommended in the Royal College of Radiologists (RCR) report ‘The Timely Delivery of Radical Radiotherapy: Standards and Guidelines for the Management of Unscheduled Treatment Interruptions. (2008)[3]. The number and range of staff groups involved in the delivery of this service has varied between centres.
A multi-disciplinary meeting was held in February 2013 under the auspices of NRIG to discuss the implications of these factors on the clinical service. It was recognised at that time that in addition to challenges for the treatment delivery service, there were a number of specific issues associated with the technical and scientific aspects of the service which would be seriously affected by extended clinical hours in a radiotherapy centre.

In early 2014 the Cancer Research UK (CRUK) document ‘Vision for Radiotherapy 2014-2024’ [4] was published. This makes reference to the need for extended hours working to improve efficient use of existing machine capacity but cautions that the benefits of 7 day working will need to be set against affordability in terms of staffing costs and the need for additional workforce capacity.

This report addresses the technical and scientific issues of providing extended clinical hours working and proposes a framework for development of an extended working hours initiative. It has been written by an Institute of Physics and Engineering in Medicine (IPEM) working party comprising a number of Heads of Radiotherapy Physics and representation from the IPEM Radiotherapy Special Interest Group (RTSIG).

2.2 Definition of a Safe Technical and Scientific Radiotherapy Service

All patients receiving radiotherapy should receive a high standard of treatment during the delivery of the prescribed course without delays or cancellations of individual treatment fractions. This requires a safe and resilient environment whatever time or day the patient attends for treatment.

2.2.1 Infrastructure

To ensure a safe clinical radiotherapy service the essential infrastructure must be established and maintained.

All imaging and therapy equipment must function within predetermined geometric and radiation tolerances for safe radiotherapy planning and delivery. This includes pre-treatment as well as on-treatment verification imaging devices and therapy equipment. Time and personnel are essential to maintain the infrastructure. The staff required to maintain the infrastructure includes engineers, scientists, dosimetrists and technologists to undertake maintenance, repair and quality assurance, determine the outcome of assessments and initiate remedial actions. A Medical Physics Expert (MPE) is required to ensure the accurate calibration of all treatment equipment (IPEM recommendations for the Provision of a Physics Service to Radiotherapy, IPEM, 2009) [5] and Medical and Dental Guidance Notes (MDGN) [6]. The time required for all the following activities; equipment maintenance, repair, QA (both machine and patient-specific), and upgrades must be included in clinical service resource calculations.

Specialist software applications are required for the preparation of complex data for radiotherapy during the planning process, namely image fusion software, virtual simulation applications and treatment planning systems. Similarly during the preparation and delivery of radiotherapy, specialist applications are essential for the recording and verification of radiotherapy, and image guided radiotherapy. Clinical Scientists with specialist knowledge
and expertise are required to commission and maintain these software applications and take full responsibility for the scientific aspects of the treatment planning process including setting up protocols for treatment. Time is required when systems are non-clinical, for software upgrades, maintenance, and validation of the integrity of data transfer between the specialist software applications and the treatment units.

A robust IT infrastructure is essential for the preparation of complex data for radiotherapy and to ensure secure data transfer between the specialist software applications and the treatment units. Thus personnel and resources are required to maintain the IT infrastructure with time allowed for hardware replacement, end to end testing and disaster recovery validation.

The delivery of a safe clinical radiotherapy service is thus only possible if time and resources are identified and available to maintain and deliver the infrastructure as outlined above. As such, the time and range of specialist personnel, including IT staff, required to ensure this infrastructure is in place must be included in the clinical service resource calculations.

2.2.2 Individual Patient Resource

To ensure the delivery of a safe and high standard of radiotherapy for individual patients, at the point of treatment delivery appropriate immobilisation must be available and treatment data that is customised and validated is essential. This will require immobilisation, localisation imaging, outlining, treatment planning and treatment data validation, to ensure the appropriate data is available in the treatment area for treatment delivery and recording. A number of essential stages in the planning of a customised treatment are undertaken without direct contact with a patient and requires dosimetrists, oncologists, radiologists, clinical technologists, therapy radiographers and clinical scientists input.

Customised immobilisation equipment is often required for a patient, thus mould room services delivered by either radiographers or clinical technologists are an essential part of the clinical service. This service may also require input for non-standard situations from oncologists and clinical scientists specialising in radiotherapy physics. Thus a range of staff are required to contribute to the design and construction of immobilisation devices, however at the time of treatment delivery it may not be considered essential to have all such staff groups represented or present.

The range of staff required to prepare the patient data for treatment may have to be available at times for multi-disciplinary meetings, however at the time of treatment of a patient, provided all the essential data are available, it may not be considered essential to have the full complement of staff present in the centre.

During a course of treatment there may be a requirement for access to specialist technical or scientific expertise when a problem arises, such as out of tolerance in-vivo dosimetry results or change in patient shape. These situations will require the advice of a clinical scientist or technologist to resolve the problems prior to subsequent treatment fractions and requires the specialist to be available within a short time frame after the problem is identified and certainly prior to the planned delivery of the next treatment fraction.
2.3 Summary of Recent Publications in the Literature

There has been very little published on the issue of extended days and weekend working. Most accounts of the use of weekend treatments have been in the context of emergency treatments (Mitera et al. 2009[7], Yeo, Campbell, and Fairchild 2012[8]) or as a means of compensating for unscheduled breaks (Dale et al.[3]) rather than as a means of increasing the capacity of a department.

In 2003 Thomas [9] modelled capacity and demand on linacs, and showed that, to keep waiting lists down, capacity must exceed mean demand by at least 10%. This, in combination with 3% for training etc., formed the basis of the 13% used by NRAG.

Two papers in Clinical Oncology by the same team from St Thomas’ (White et al. 2007)[10], (Calman et al. 2008)[11] gave a comprehensive review of the situation in 2007, including results of a survey of patients, and a survey of practices in UK departments, based on questionnaire responses from 52 departments. Issues of servicing (in hours and out of hours) were discussed; the mean amount of time spent on servicing and QA (excluding daily checks) was 247.2hrs per machine (range 129.1-429.5) of which on average 35.2% (range 0-100%) was done out of hours (defined as before 09.00hrs or after 17.00hrs).

In 2006 Routsis, Thomas, and Head [12] modelled different patterns of radiographer staffing for an extended day, and concluded that all gave fewer treatment hours per radiographer than a standard 7.5 hour day with breaks. The longer the day, the smaller this effect became.

The NRAG Report[1] advised that only half the machines in a department should run an extended working day, and recommended a 5 day week, saying “internationally radiotherapy practice is based on a 5 day working week and recommended fractions for radical treatment have been developed and proven over the years on this basis. Alterations in the working week to include Saturdays for radical treatment would therefore pose complex scheduling problems. Only a 7 day week would avoid this but NRAG advise that this is unlikely to be feasible given the national and international shortage of specialist staff needed to run the service. It is also not clear that a 7 day service would be popular with patients or that it would be attractive to radiography or physics staff (once numbers have increased) - leading to further recruitment and retention difficulties. Where departments open on a Saturday, Sunday or bank holiday NRAG recommend that a full service should be operated – this does not mean that all linacs in a department need to be in operation. However, there should be appropriate support for patients available including reception staff and the ability to obtain refreshments. In addition to the therapeutic radiographers delivering the treatment, physics and medical staff would also need to be available to support treatment.”

Probst et al. in 2012[13] suggested a link between extended working days and staff ‘burnout’, which could result in radiographers leaving the profession. This may limit the ability of departments to expand radiotherapy capacity. Radiotherapy Clinical Scientists and Therapy Radiographers both appear on the UK list of shortage occupations (Home Office 2013).[14]
The joint document from IPEM, Society of Radiographers (SCR) and RCR published in 2013 “Guidance on the Management and Governance of Additional Radiotherapy Capacity”[15] mainly describes increases in capacity by provision of additional machines and satellite departments. However mention is made of the ‘pros and cons’ of servicing at evenings and weekends, noting that the former may not be an option if there is a long extended working day, and the latter, for a small staff group, the frequency that each member is required to be available may impact on staff morale. It recommends the use of Malthus(Jena et al. 2012)[16] to predict demand for radiotherapy.
3 The Key Components of a Radiotherapy Physics and Technical Radiotherapy Service

A safe, resilient and modern radiotherapy service requires ongoing non-clinical activities to maintain and develop the infrastructure. These activities are defined in the following section. They could be undertaken in parallel with the clinical service if resources permit or outside the hours of the clinical service. However, they are not optional and require adequate resources and access to equipment to ensure they are delivered safely and to a high standard.

3.1 Non-Clinical Activities Required to Deliver a Safe Clinical Service

3.1.1 Planned Maintenance
For all radiotherapy equipment, the manufacturers specify a schedule of planned maintenance inspections (PM). Depending on the company and the department, these may either be carried out by the company or by in-house engineers. The schedule may also involve the periodic replacement of parts with a known lifetime.

3.1.2 Corrective Maintenance
When a QA measurement falls outside an agreed tolerance, work has to be carried out to return the parameter to within tolerance. Minor work will frequently be carried out within the QA schedule or scheduled to minimise disruption to the clinical service. More major work will generally count as an unplanned equipment repair.

3.1.3 Unplanned Equipment Repairs
When a machine breaks down, has a fault which significantly impairs performance, or has a QA measurement outside a defined tolerance, it has to be removed from clinical use until it is repaired. This work is generally unplanned, and so has the potential to disrupt patient treatments. In some cases, where an intermittent fault occurs, or a parameter is heading towards a tolerance, there is some choice available about when to do this work, so it may be counted as corrective maintenance by some departments; however, the shorter the notice, the more it is in effect unplanned. In a department working extended hours, unplanned repairs are very disruptive of patient schedules, and this can be alleviated if the department has a service efficiency machine.

3.1.4 Machine Quality Assurance; Regular and following Upgrades.
IPEM Report 81 (which is currently being revised)[17] specifies a programme of regular checks to be carried out on radiotherapy equipment. There are daily checks that must be carried out before the machine is used each day, and more detailed checks carried out at intervals such as weekly, monthly, quarterly and annually. The rationale for the frequency of some checks is given in IPEM Report 92[18]. Each department has a QA system that specifies the quality control (QC) checks to be followed. In addition to these regular checks, there are extra checks that must be carried out after repairs and upgrades. The nature of
these checks will depend on which components have been changed or repaired; for example the replacement of a transmission ionisation chamber would require additional dosimetry checks, as laid out in the guidance for definitive calibrations in the Medical and Dental Guidance Notes MDGN, (which is also currently being revised)[6]. Upgrades to computer hardware may additionally require checks on the functioning of software, as described below.

3.1.5 Software Quality Assurance

This applies to both routine QA and QA required following software upgrades. Radiotherapy equipment is usually computer controlled. A computer system called a Radiotherapy Management System (RMS) links the systems in a department. RMSs in use in the UK include Aria (from Varian) and Mosaiq (from Elekta). A failure of an RMS can prevent treatment on all machines in the department at the same time. There are also software systems specific to each individual piece of treatment or imaging equipment. Software within Treatment Planning Systems (TPS) is used to calculate the parameters required to deliver the required radiation dose distributions for individual patients. The QA system will include regular checks on the software systems.

Software upgrades are typically required at intervals of 1-2 years. Following an upgrade, a series of tests are required to assure that the software is running as expected. For an RMS upgrade, the upgrade typically takes 2 days, with a further 1-2 days required for QA tests.

3.1.6 Cross-Calibrations and Reference Dosimetry

The dose of radiation received by patients must be traceable to national primary standards. To ensure this, each department has access to one or more secondary standard dosimeters, which are calibrated at the National Physical Laboratory. Departments follow codes of practice published by IPEM to ensure consistency of reference dosimetry. These codes require that the field instruments used for routine measurement of dose are cross-calibrated annually by inter-comparison against a secondary standard. This can take 1-2 days per annum on a multi-energy machine. Where machines are not beam-matched, this needs to be repeated on each machine.

Inter-departmental audit involves clinical scientists from one centre performing measurements on equipment in another centre in order to validate the accuracy of reference dosimetry and related measurements. This is coordinated by regional audit groups of the RTSIG interdepartmental audit sub-committee.

3.2 Clinical Activities

To ensure the delivery of safe and state of the art radiotherapy for individual patients, customized treatment data must be validated prior to treatment.

3.2.1 Patient-Specific QA for Complex Treatments.

Complex treatments are usually the more technologically advanced treatments, which at the time of writing would be considered to include Intensity Modulated Radiotherapy (IMRT), including rotational delivery such as Helical TomoTherapy and Volumetric Arc Therapy.
(VMAT), Stereotactic Ablative Radiotherapy (SABR) and Stereotactic Radiosurgery (SRS). However other techniques are likely to be developed for which the same principles would apply.

Current Peer Review measures [19] require that patient-specific QA measurements are performed for IMRT, except in certain circumstances described below. Patient-specific QA involves delivering the treatment plan to a phantom, with measurements being performed with chambers, films, detector arrays or Electronic Portal Imaging devices (EPIDs). This QA involves time on the machines, and must be scheduled to be performed after the plan has been produced and before the patient starts treatment. These measurements can be reduced or dispensed with in some cases where at least 10 patients have been treated with the same treatment procedure (class solution) for similar body sites and where an independent check of monitor units/dose has been carried out for the treatment plan. For other complex non-IMRT treatments such as SABR and SRS patient-specific QA is also carried out, especially in cases where no reliable independent Monitor Unit (MU) check software exists or the treatment fluence is too modulated to rely on a single point MU check.

3.3 Clinical Service Development

Maintaining a modern radiotherapy service requires the continuous implementation of new radiotherapy techniques and procedures. Guidance can often be provided through clinical trials or national recommendations but local validation is required before clinical implementation. This activity, which cannot be considered optional, will usually require access to the therapy equipment. This can be undertaken in parallel with the clinical service if resources permit or outside the hours of the clinical service. However adequate resources must be available for safe implementation.

3.3.1 New Techniques

It is the nature of the work of a radiotherapy department that new radiotherapy techniques are continuously being developed and implemented. This work includes both new techniques and implementing a technique developed in another centre and requires access to linear accelerators by clinical scientists. This access is required to measure beam data specific to the new technique, to carry out relevant phantom measurements, and finally complete end-to-end tests of all the stages in the process to provide validation of the new technique before it is used clinically. Examples of recent developments in UK centres include rotational IMRT techniques, such as VMAT, the use of flattening-filter free beams (FFF), SABR and SRS.

3.3.2 Clinical Trials

Radiotherapy centres are encouraged to participate in single-centre and multi-centre clinical trials. For all National Institute of Health Research Clinical Research Network (NIHR CRN) Portfolio trials that include a radiotherapy component, centres are required to be credentialed by the Radiotherapy Trials Quality Assurance (RTTQA) team. The RTTQA was established to ensure that patients in all National Cancer Research Institute (NCRI) radiotherapy trials adhere to a trial protocol, and are treated according to nationally accepted
standards. This is an integral part of radiotherapy clinical trials and serves to minimise variations thus ensuring clinical trial outcomes reflect differences in randomisation schedules rather than departures from the trial protocol. Credentialing is done by a mix of questionnaire, planning exercises and measurement visits. These visits depend on the trial being credentialed, but a typical IMRT credentialing visit may involve individual field measurements, combined field measurements and dose point measurements, which all require access to a linac.

3.3.3 Research and Development

In addition to the two areas above, a department may have a programme of research that requires other measurements to be carried out on linear accelerators. For example the department may be devising new forms of dosimetry, new computer models for modelling dose deposition, or new methods of imaging the patient for IGRT.

3.4 Infrastructure Maintenance

3.4.1 Buildings and Estate Maintenance

Estates departments will require access to treatment rooms, and to associated plant rooms, to carry out maintenance work. This cannot be carried out at the same time as treating patients.

3.4.2 IT Infrastructure Maintenance, e.g. Database Backups, Operational Upgrades

In addition to the software upgrades described in 3.1.5 above, there will be a requirement by the IT department for access to the system for IT infrastructure maintenance, for example to the routers and switches in the network infrastructure, upgrades to operating systems, and back-ups of data. Some of these tasks can be performed without affecting the service, whilst others will need to be scheduled to take place at times when the centre and hence equipment is not in clinical use.

Summary of Key Points

- All radiotherapy equipment needs a schedule of planned maintenance.
- Where a machine breaks down or fails a QC test, unplanned repairs or corrective maintenance is required.
- Upgrades to hardware and software require time to be scheduled, both for the upgrade itself and for QA following the upgrade.
- Time must be scheduled for annual inter comparisons and periodic dosimetry audits.
- Patient specific QC measurements for complex treatments such as IMRT and SABR need to be scheduled to fit in with patient pathways.
- New techniques, clinical trial work and other R&D all require time on treatment equipment to be allocated.
• Infrastructure maintenance can also impact on machine availability.
• Close cooperation with Trust IT departments is essential to ensure that the IT infrastructure meets the Radiotherapy Department’s requirements, is available as necessary, and provides sufficient redundancy to withstand incidents such as network failures or to provide disaster recovery.

4 Models of Extended Clinical Hours Working

4.1. Extent of Clinical Service

Until recently the clinical hours of service have typically been between 09.00hrs and 17.00hrs Monday to Friday, with maintenance and manufacturer’s support accommodated within those hours. The timing of QA, service development and other technical and scientific activities have depended on local practice, but may take place in the evening or at the weekend when the clinical service was not operational.

Within this document three models of extended hours working are considered, each model has implications for the non-clinical activities which are required to maintain the service infrastructure, ensure safe delivery of complex radiotherapy and service development.

4.1.1 Extended Week Day Working

In this scenario the clinical service would be extended to deliver radiotherapy from completion of the daily QA commencing at 07.00hrs until 21.00hrs Monday to Friday, with all indirect clinical services such as infrastructure maintenance, including PM, QA and manufacturer’s support to be delivered during this time. Weekends would be available for emergencies and some palliative patients as outlined in the NRAG report [1]. Service development would either require access during the hours of the clinical service or at the weekends.

4.1.2 Six Day Working

This scenario would include the extended week day working outlined above and similar hours of clinical service delivery on a Saturday. If Sundays were considered to be a suitable day to undertake manufacturers’ planned maintenance and upgrades over a year this scenario would result in a significant amount of the clinical equipment on a Saturday or Monday also being required for extended sessions of planned maintenance and infrastructure upgrades. The only time available for service development and some patient-specific measurements would be a Sunday, or time would have to be scheduled within the clinical service hours.

4.1.3 Seven Day Working

A clinical service would be delivered seven days a week, including bank holidays. Over a year all the time required for maintenance, QA, service development and infrastructure maintenance would have to be scheduled in the time nominally allocated to the clinical service.
4.2 Alternative Provision of Additional Clinical Hours

Each of the three scenarios described above would require additional staff to deliver the service. The number of staff and staff groups involved would be dependent on the clinical service offered during the extended hours. Thus the revenue consequences of increasing the hours of the clinical service would need to be modelled on the clinical service agreed locally. If extended hours working were to be permanent then there would be a number of long term consequences. Sufficient clinical scientists and clinical technologists would be necessary to ensure adequate staffing levels over the extended clinical hours and to undertake the non-patient but essential activity on the linacs. This has implications for the commissioning of clinical scientist and technologist training places with a lead in time for trained clinical scientists of at least three years.

An alternative strategy for consideration would be to increase the provision of additional treatment and imaging equipment. During the hours of the clinical service the centre would operate with some spare capacity as recommended in the NRAG report [1]. This clinical capacity would need to be sufficient to accommodate fluctuations in the clinical workload as well as being used for maintenance, QA, and service development concurrently with the clinical service. In the event of unexpected maintenance the non-clinical equipment capacity could revert to clinical service, thus limiting the impact of any downtime on the clinical service. Whilst this would negate the requirement for additional staff required for an extended hours service, it would have implications for the capital and revenue costs of the infrastructure.
5. Manufacturers’ Support for Extended Hours Clinical Service

The three major manufacturers supplying megavoltage radiotherapy equipment in the UK were consulted about the implications of providing support services for the three extended hours models described in section 4.1. These companies were Accuray (supplier of TomoTherapy and Cyberknife), Elekta, and Varian Medical Systems (Varian). Elekta and Varian are both suppliers of traditional linear accelerators. It is likely that any extended hours working will have greater impact on the companies with the lower engineer to machine ratio.

The manufacturers outlined the service implications when machines were not replaced within the NRAG [1] recommended 10 year life span. These were identified as issues of increased complexity with newer equipment, training, maintaining engineers' competence over a range of equipment of different ages and thus technology, as well as the technical capability of the equipment. For example, the recent increase in the number of IMRT treatments, together with IGRT, means that an increasing number of the more complex components are failing. These include mechanical components such as treatment couches and x-ray tubes on IGRT systems. This results in greater down time, and more QA following replacement. It is possible that in the future, warranties for some components may need to be based on machine operating hours rather than lifetime, as at present.

In addition, obsolescence can occur more often during the lifetime of the equipment so it is quicker to replace whole components rather than repairing them on site, leading to increased shipping and delivery costs. It also becomes increasingly difficult to get older components repaired, especially where manufacturers employ sub-contractors and the design may have changed. Suitable replacements become more costly because of the need to maintain manufacturing standards on such components.

Hence, replacement of equipment after 10 years would facilitate the provision of radiotherapy on an equipment portfolio suitable for modern radiotherapy techniques for the benefit of the patient.

5.1 Service Provision by Manufacturers

Within a service contract manufacturers provide a number of facilities to ensure satisfactory uptime for equipment and software. Access to each facility would be dependent on the service contract agreed with individual Trusts.

The manufacturers reported that quite a number of Trusts do not currently include maintenance in their service contracts thus leading to false assumptions about the true operating costs of radiotherapy equipment. In these trusts, the costs of in-house maintenance must be included when calculating the overall operating costs.

5.1.1 Service Desk Support

In order to obtain maximum benefit from service desk support it is important to have a trained engineer on the hospital site who can liaise with the manufacturer. Unfortunately many Trusts with full maintenance contracts do not currently employ their own radiotherapy
engineers. In the event of breakdown this arrangement can leave Trusts with an idle machine until a Field Service Engineer (FSE) is on site, resulting in greater clinical downtime for an extended hour’s service.

Employing radiotherapy engineers to liaise with the manufacturer’s service desk would help to reduce clinical down time which becomes more critical within an extended hours service.

5.1.2 Maintenance or Repair out of Clinical Hours

All manufacturers would require the presence of a Trust employee during any maintenance or repair out of clinical hours. This is because of the Health and Safety implications of lone working on high voltage equipment. Ideally, such a person would need to be a Trust engineer who is able to liaise with the FSE with sufficient knowledge and expertise to enable the FSE to carry out his work within optimum time scales. Currently a number of Trusts with ‘out of hours maintenance’ contracts supply security staff, but these do not have sufficient engineering expertise for this situation. Trusts will, therefore, need to have a sufficient number of in-house engineers if they wish to carry out any planned or breakdown maintenance out of current clinical hours. The lack of availability of suitable engineering staff and the costs of training such staff are important factors to consider, but where possible having in-house engineering teams enables more efficient use of any extended hours. Manufacturers and Trusts are bound by the European working time directive which may lead to the need for more FSEs, as more than one engineer may need to be deployed to any service call or planned maintenance visit.

5.1.3 Equipment Repair and Engineer Availability

The main concern from the manufacturers’ perspective is the probable need to significantly increase their staffing base, both field service engineers and help desk support, to cover any extended hours working. Whilst this is undoubtedly possible, the manufacturers have stated that there would be a time lag of some 2-3 years to employ and train sufficient staff to be able to support delivery of any form of sustained extended hours working to the UK radiotherapy community.

For some machine breakdowns, where the cause is not immediately obvious, the FSE requires backup support from other engineers in the field. This will be more limited with an engineering support base spread over more hours but without an increase in overall engineer numbers, as fewer engineers will be working at the same time. In addition some engineers are more experienced in particular aspects of machine performance, and there may be a delay before they are available, leading to increased downtime. This is particularly relevant for software support and again supports the need for increased numbers of FSEs.

Having an in-house dedicated radiotherapy engineering team will ensure that more work can be carried out during extended hours as a quicker response to any breakdown can be made, as well as the provision of some routine maintenance or QA without the attendance of the manufacturer’s FSE.

5.1.4 Availability of Spare Parts
The provision of any extended hours service would require the need for spare parts to be ordered and dispatched at any time upon the FSE’s request. Obtaining spare parts from a central warehouse would require it to be staffed during the night and weekends, which will ultimately result in increased costs for the customer. While spare part provision is the manufacturers’ responsibility they are all dependant on courier companies for delivery. The UK radiotherapy market is a low-volume customer as far as courier companies are concerned, and the manufacturers therefore have no bargaining power or influence over the service provided by couriers. Therefore, while it may be possible to provide engineering support out of clinical hours, it may not be possible to obtain spare parts in a timely manner, which could lead to delays in the return of equipment to clinical use. These factors contribute to a significant cost increase for next day delivery, even for small components.

In addition there are sometimes problems in receipt of replacement parts at the individual Trust. Trusts would need to ensure that there was an adequate ‘round the clock’ goods inwards service to facilitate delivery of spare parts. It is currently not always possible to deliver large items before 09.00hrs because of the need for two people to lift, and hence the delivery personnel require the assistance of a suitable Trust employee at the point of delivery to the Trust.

Although some manufacturers make use of a central spares base, this only accounts for about 10% of orders. It is too costly to hold expensive spare parts and therefore shipping large items at short notice from abroad incurs additional charges, sometimes of the order of £1K per delivery. Capacity on freight aircraft for larger items is also sometimes an issue. This cost will inevitably be reflected in increased charges to the customer.

5.1.5. IT Support

All manufacturers reported a significant increase in the difficulties of negotiating the security requirements of Trust IT departments. Trusts will need to commit to better working with radiotherapy manufacturers than is currently the case. For example, internet access is often required by the FSE when they are on site, to enable them to access the manufacturer’s engineering information remotely, and access with administrative rights to systems is sometimes an issue for non-Trust staff. Similarly manufacturers require the facility to establish ‘remote access’ into the equipment for remote diagnostics and monitoring of performance; however access is often limited by IT departments.

In order to comply with EU patient data regulations, no patient data is allowed to be exported outside the EU and as the manufacturers are all global companies there are sometimes issues with their own systems being backed up to systems outside the EU. Even printing off job forms can sometimes cause an issue with Trusts, as can screen shots containing patient data. Hence Trusts will need to ensure that their IT departments are fully aware of the RT manufacturers’ requirements in order to support an effective extended hours RT service, whilst still recognising that IT Departments have to be aware of Caldicott requirements.

Software and hardware upgrades are currently normally carried out at weekends when there is no clinical service. Migration of the database is usually the first step in any software upgrade and this can take several hours during which no service access is possible. This is then followed by the upgrade itself and any associated QA post the upgrade. If a department is running a 7 day extended hours service then, when an upgrade is required, there will be
times when a 2-3 day break in treatment will need to be scheduled for all patients. Major
software upgrades take place at least every three years with other upgrades being required
at greater frequency. Similarly operating systems can become obsolete very quickly and
usually need replacement within 5 years, requiring a similar interruption to service.

The monitoring of down time currently depends on individual contracts for some
manufacturers. A limited treatment day allows manufacturers to say that after normal clinical
hours a machine is no longer ‘down’ even if it is being worked on. This ‘space’ will be
reduced for any extended hours service and presents challenges which will need to be
addressed in considering up-time guarantees.

5.2 Factors affecting Manufacturers’ ability to Deliver Extended Hours Service

5.2.1 Training
It takes approximately 10-12 months to train an engineer who is recruited with relevant
transferrable skills and experience. New recruits come from engineering elsewhere, often
ex-RAF, although this latter source is likely to reduce in the future.

5.2.2 National Agreement
There would need to be a national agreement for weekend working across the country with a
long term commitment. It is not economically viable for manufacturers, who are currently
tasked with reducing overtime and other overheads within their own companies, to train a
large cohort of engineers with the long lead-in time required, without some indication from
the Radiotherapy community as to how extended hours are likely to be introduced on a
national basis.

5.2.3 Timeframe for Implementation
The manufacturers indicated that it would take 2-3 years to be able to fully support any
extended hours service on a national basis.

Whilst none of the above factors are insurmountable it is clear that the manufacturers do not
currently have the infrastructure to support extended hours. It is important that the
Radiotherapy community continues to engage with them, if possible with a national
perspective, to ensure development of extended hours services in a safe and efficient
manner.

5.3 Cost Indicators for Provision of Extended Hours

The major cost to manufacturers will be in the employment and training of more field
engineers with some parts of the country requiring more than others. The three
manufacturers have estimated that there will be an uplift of approximately 70% to current
service and maintenance contract costs, to enable them to provide help desk and FSE
provision 7 days a week. Annual costs could be of the order of £100K+ per linac depending
on the level of service contract and complexity of machine involved. There was a range of
cost estimates for both extended hours, Monday to Friday, and Saturday working. Accuray
engineers already work into the evenings during the week, and this is included in their
current service contracts. Only an Accuray FSE can order spare parts so that can only be done when they are on site. Both Elekta and Varian indicated that working until 9pm Monday to Friday with full manufacturer support, and/or carrying out planned maintenance on Saturdays would result in a similar and significant cost increase.

<table>
<thead>
<tr>
<th>Summary of Key Points</th>
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<tbody>
<tr>
<td>• Engagement with the manufacturers at a national level is recommended for the implementation of extended hours in an efficient manner. A national agreement will be required for a countrywide extended hours service. Implementation time following agreement is likely to be 2-3 years.</td>
</tr>
<tr>
<td>• Trusts must employ a sufficient number of trained engineers dedicated to Radiotherapy to liaise with FSEs, for the safe introduction of any extended working hours.</td>
</tr>
<tr>
<td>• Trusts will need to ensure due consideration is given to logistical issues for extended hours manufacturer support such as arrangements for delivery of spare parts.</td>
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<tr>
<td>• Trusts must ensure that their IT departments fully engage with manufacturers in order to facilitate efficient working practice.</td>
</tr>
<tr>
<td>• A 7-day service must plan for 2-3 day breaks in treatment service to facilitate software and hardware upgrades. A 6-day service will require 1-2 day breaks in treatment service.</td>
</tr>
<tr>
<td>• Uptime guarantees may need to be revised by manufacturers.</td>
</tr>
<tr>
<td>• An uplift of approximately 70% on current manufacturers’ maintenance contracts is anticipated for 7-day extended hours working.</td>
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6 Implementing an Extended Hours Service

A number of stages in the development of a permanent extended hours radiotherapy service are required. For the purposes of this document those stages relevant to the scientific and technical aspects of the service are considered. It is acknowledged that the initial consideration must be the intended clinical service. Implementation should be subject to ongoing review.

6.1 Defining the Extended Hours Service

6.1.1 Clinical Service
In order to implement an extended hours service it is important firstly to define the level of clinical service required during the period under consideration. This covers issues such as the case mix, number of fractions, complexity and techniques to be offered, together with considerations regarding gaps in treatment and the policy regarding the re-planning of patients. In defining the clinical service during the extended period it is essential to recognise the impact of both the scope of the service being offered plus the additional time period covered. Extending the treatment day by a few hours each week is likely to require less planning and resources than treating 6 or 7 days a week.

6.1.2 Service Level Support
Having determined the level of clinical service required, this leads on to decisions regarding the service level components that will be needed to support the clinical service. For a complex case mix including head and neck patients treated using IMRT/VMAT it may be necessary to have mould room staff available to deal with shell fitting/positioning issues, if no beam matched linac is available then treatment planning may be required to manage plan transfer issues or to replan. If patients are to have their first fractions during the extended hours period then in-vivo dosimetry may well be needed, together with imaging capabilities, so staff with appropriate experience will be required during this period.

Time needs to be identified and scheduled for the non-clinical activity required to maintain the infrastructure, ensure safe delivery of advanced treatment techniques and service development.

6.1.3 Response Time and Capacity
As well as the service components required during extended hours, it is important to consider response time and capacity, particularly for 6 or 7 day working. Traditionally, it has often been acceptable to respond by the following working day if an issue has been encountered with either a patient's treatment or a machine related issue. However, if a problem occurs on a Friday and the patient is scheduled to be treated throughout the weekend, then a response before the following Monday is clearly needed. In larger departments a number of issues could arise at the same time requiring capacity planning. In order to minimise the number of gaps in treatments the availability of linac engineers to respond to breakdowns rapidly will be important, especially for smaller departments.
6.2 Scenarios
Three levels of clinical service are defined and considered:

- Treatment Delivery Service
- Partial Clinical Service
- Full Clinical Service

6.2.1 Treatment Delivery Service
This service would be limited to delivery of radiotherapy fractions only.

It would be necessary to ensure that the infrastructure is in place and the patient cohort selected so that no immediate problems were anticipated with any treatment fraction.

It should be clearly understood that if there was a problem with a patient’s treatment that could not be easily resolved, treatment would be suspended until the resources were available to resolve the problem safely. It must be ensured that the time delay in resolving any problem is not detrimental to the patient.

The major risk in this scenario would be if the intended treatment linac became unavailable for any reason e.g. break down. To provide resilience an alternative linac should be available to transfer patients to.

Many centres operate an ad hoc extended hours Treatment Delivery Service as a means of providing additional capacity with minimal resource implication, often to minimise gaps in treatments around public holidays. Typically the treatment day would be extended for a few hours during the working week and scientific and technical support would be provided, if considered necessary, by means of a rota or an on call arrangement. However, the case mix may be limited and the decision may be made not to start new courses during the extended day due to resource considerations.

6.2.2 Partial Clinical Service
For the Partial Clinical Service a more routine pattern of working would be operated for a longer period. While not operating at the level of a Full Clinical Service the Partial Service will often have a more extensive case mix and allow for new courses to start, although some clinical service components may not be provided e.g. Mould Room or Brachytherapy. This level is usually a natural progression from the Treatment Delivery Service and while offering efficiencies the various issues need careful consideration.

The extent of the clinical service that is to be delivered at a given time would be locally determined. This would dictate the range of staff groups that are required to be available within the radiotherapy centre for that service. The restricted facilities to be made available during a clinical session would need to be determined and would depend on the intended range of treatments to be delivered, numbers of patients and equipment available. Clear written protocols would need to be in place to ensure that the boundaries required to deliver a safe service were not overridden.
An extensive risk assessment would best inform the extent of the resources that would be required for a safe radiotherapy service in this situation. A number of these risks may be reduced or mitigated by not utilising all available machines during the hours of the partial clinical service so that patients can be transferred to another machine in the event of machine breakdown.

An alternative approach to planning a partial clinical service would be to consider the resources available at given times and use those to guide the selection of suitable patients for treatment and thus the extent of the service.

6.2.3 Full Clinical Service
The Full Clinical Service requires sufficient staff to be in place from all staff groups involved in the patient journey within radiotherapy, to manage all clinical situations and as such the elements to ensure a complete technical and scientific service are required.

All the resources necessary would be present to manage unforeseen situations, unexpected maintenance, or any problems with patient treatment delivery.

Additional personnel in each staff group would be required to deliver this service in approximate proportion to the increased clinical hours.

Additionally, section 4 defines three approaches to extending clinical hours:
- Extended Weekday Working
- Six Day Working
- Seven Day Working

While these do not necessarily parallel the above levels of clinical service they do represent a progression of increasing amounts of time available for the clinical service.

Departments often start using Extended Weekday Working to provide some additional capacity with low resource impact. One consequence of this approach is that there is less time for maintenance, QA and manufacturers support during the working week.

Six Day Working provides additional resources when used in addition to Extended Weekday Working and is most likely to be used with a Full or Partial Clinical Service. Again, there are consequences of this pattern for the scheduling of the non-clinical activity required to maintain the clinical service, as described in Section 3.

For both Six and Seven Day Working it becomes necessary to schedule infrastructure work within the extended day, but there are areas of work which affect all treatments, such as IT infrastructure maintenance. It may be possible to schedule such activity between 21:00hrs and 07:00hrs but further work outside the main maintenance period would have serious impact.

Established six or seven day working would require additional staff resource for the following reasons:
- Scheduling existing staff to cover the extended period will under-resource the normal working week and has the potential to lead to operation at an unsafe level.
• The use of extended hours working to provide extra capacity would result in increased activity as workload will rise in proportion to the number of additional treatment courses.

• The staff profile will have to be maintained for a full clinical service over the six or seven day working, so additional staff at all grades including higher ones will be required.

These are likely to be the most resource intensive options but the income resulting from additional throughput may offset the expenditure. This is dependent on pay rates for unsocial hours etc. and is discussed in greater depth below.

6.3 Resource Requirements
Having considered the clinical service required during extended hours together with the service components and response time needed, it is important to consider the staffing levels, skill mix and equipment requirements.

6.3.1 Staffing
It is vital to ensure that staff numbers and skills are adequate to provide the service component within the required response time. For a Treatment Delivery Service operated during Extended Weekday Working a combination of shift working and on call arrangements may be adequate. However for a Partial Clinical Service operated over a longer working day, or six or seven day working, additional staff will be required.

IPEM [5] has recommended minimum scientific and technical staffing levels for a normal day, which are included in Peer Review measures [19]. The guidance (currently under review) states that:

‘The numbers indicate staffing requirements to allow for provision of a service during a standard 8-hour working day. Additional resources are required to account for extended working hours and/or weekend working for treatment, planned preventative maintenance, repair or quality assurance work.’

This document splits staffing numbers into ‘equipment dependent’ and ‘patient dependent’ factors.

For a Full Clinical Service, rather than simply multiplying existing staffing numbers by the ratio of new to existing hours covered, a more robust approach may be to scale the equipment dependent numbers for those staff required to be scheduled to cover the treatment day according to the additional time, but scale the patient dependent factors by the ratio of courses of treatment. That said, if the time is fully utilised, the staffing requirements will also scale with the extra time.

A more cost effective approach would be to use a Partial Clinical Service for Extended Week-Day or Six Day Working. In these circumstances, it is accepted that not all services will be available and the available resources can be prioritised for use in the most clinically appropriate areas. This course of action will result in a smaller increase in staff numbers.

It is recognised that extended day working could become an established trend within radiotherapy requiring additional staff numbers. It is important that adequate numbers of
Clinical Scientists and Clinical Technologists are trained under the Modernising Scientific Careers (MSC) programme. There is currently a shortage of Clinical Technologists that prevents the full potential of skill mix efficiencies being realised in radiotherapy. If appropriate staff are unavailable then the scope and scale of the service should be adjusted rather than risk unsafe working.

6.3.2 MPE involvement
The MDGN [6] require that a MPE be ‘closely involved’ in radiotherapy with specific responsibilities for management of the treatment planning, QA and dosimetry processes, but there is no requirement that an MPE be present for every treatment. IPEM staffing level guidance [5] further states that:

‘This expert must be specifically trained in Radiotherapy Physics and the implication of the requirement is that such a physicist should be available on site for at least part of the day, wherever radiotherapy is carried out.’

This arrangement suggests a proportionate response to the likelihood of a need for advice arising during a normal working day, and implies that a response by the next working day is adequate.

To that end it is suggested that local arrangements can be agreed and ‘risk assessed’ for anything less than a full clinical service. For a full clinical service over 7 days the IPEM guidance suggests that an MPE be on site for at least part of each day.

6.3.3 Skill Mix
Skill mix considerations become of increasing importance for the Partial and Full Clinical Service, and individual departments will need to carefully consider the arrangements they put in place. It will be important to identify the more complex interventions requiring the higher skill levels within any staff group that is involved during extended working (both clinical and non-clinical), and make arrangements for sufficiently skilled and experienced staff to be available.

Specific arrangements, including those for MPE involvement, will depend on the clinical service required. It may be more difficult for smaller departments with less experienced staff as they may experience difficulties in providing safe levels of cover for extended periods without additional staff recruitment.

6.4 Equipment
Both the capacity and capability of the radiotherapy treatment equipment will have a bearing on the additional throughput provided by extended hours working. The requirement for a SEM as stated in the NRAG report [1] is justified by the activity figures from the recent survey, section 7. This facility allows for QA to be carried out during the working day and provides resilience in the service in the event of machine breakdown, enabling the continuation of treatment provided the machines are sufficiently matched or backup plans are available. It also provides capacity for the monthly variation in patient numbers experienced by all departments.
Some machines are capable of faster IMRT treatment delivery using rotational techniques such as VMAT and RapidArc. Additionally, machines with FFF beams can deliver high dose rates and are particularly useful for the large dose per fraction treatments such as SABR and other hypo-fractionated techniques. However, it is important to note that additional techniques and equipment capabilities require more QA time to ensure patient safety.

Making more clinical use of the treatment machines increases pressure on servicing and QC arrangements, and also creates capacity issues in the event of machine breakdown. This needs careful consideration, particularly in smaller departments where there is less capacity for transferring the additional workload to additional machines. Contingency arrangements to cover major breakdown involving nearby radiotherapy centres may need to be considered.

6.4.1 Servicing, QA and Development
It is essential that within any extended hours model adequate non-clinical time is scheduled to ensure a safe infrastructure with adequate PM and QA, time for patient QA and service development and associated activity.

For departments that undertake servicing and QA within normal hours the option of partially or wholly moving these tasks to the extended hours period can be attractive, but as extended hours working increases, scheduling servicing and QA outside clinical time will become increasingly difficult. It is however essential that within the whole week adequate provision has to be made for maintenance, QA, service development as described above.

Manufacturer-provided servicing has been discussed in section 5 and similar issues arise with in-house servicing and QA. Extending working hours from a five day week to one or more days at the weekend limits the scope of servicing outside clinical hours, requiring that servicing be scheduled within the extended treatment week.

6.5 Governance Considerations
There are a number of options for implementation of extended working hours in radiotherapy but it is important to consider patient safety, cost and clinical effectiveness. The baseline scientific and technical requirements for a safe radiotherapy service are defined in section 2.

When implementing extended working hours it is important to identify and minimise the risks. A risk assessment of the planned extended hours service should be made, and repeated whenever there are any major changes. It is possible that risks may be difficult to manage within existing budgets and to that end the requirements of the service may also need to be adjusted, as reflected in the feedback loop in figure 1.
Figure 1. Flowchart for Developing a Model of Extended Hours Working
Summary of Key Points

The case mix, capacity and response time should be defined for the clinical service during the proposed extended hours working.

The service level components required from Radiotherapy physics and technology should be defined based on the planned clinical service.

A model of the proposed extended hours working should be defined giving details of:
- The level of working (Treatment delivery / Partial Clinical Service / Full Clinical Service)
- The period of extended hours working (Extended work day/ Six day working / Seven day working)
- Additional staffing and skill mix requirements
- Scheduling of QA/Servicing and development work, including IT infrastructure maintenance

A risk assessment including the contingency arrangements should be made for the extended hours work covering:
- Clinical risks
- Physics and technical risks
- Equipment failure

The workload at which the capacity of the remaining equipment and staffing resources would be exceeded in the case of a major equipment breakdown should be defined

Arrangements for the regular review of the clinical effectiveness and safety issues arising from the extended hours working should be made
7 The Current Situation in the UK.

A survey was produced and distributed via e-mail to the UK Heads of Radiotherapy Physics in December 2013 with the aim of collating objective information concerning times for equipment QA, patient-specific QA and additional tasks including in-house and manufacturer upgrades of equipment, all of which require direct access to linacs. This was necessary due to changes in practice since 2007 e.g. increases in patient-specific QA and patient throughput, complexity of techniques, as well as the need to determine more objectively how much non clinical time is required to support a clinical RT service. Much of this time is currently unaccounted for. Further information was requested on the availability of decant bunkers and service efficiency machines as proposed by NRAG [1], and on the availability of MPE support as well as funding for extended day working.

The survey was requested to be completed with information as of 1st January 2014. Replies were received from 32 of the 62 centres polled in the UK with results detailed below.

The responding centres reported a total of 164.5 clinical linacs with the number of linacs varying from a maximum of 12.5 linacs, minimum of 2 and mean/centre of 5.1. This may be taken as a reasonably representative sample of small, medium and large departments when compared with the distribution of linacs/centre taken from the RT Dataset (RTDS) for England which reports a maximum 16, minimum 2 and mean of 5.4.

7.1. Operational Hours

![Current Operational Hours of RT Centres](image-url)
**Figure 2.** The current reported operational hours of the radiotherapy centres.

It is clear that many centres are already operating on an extended day basis, with over 50% of centres opening between 08.00hrs and 8.30hrs and a majority still operating at 18:00hrs. For the purpose of discussion in the remainder of this section, the 'standard' working week will be taken as 09.00 – 17.00hrs Monday – Friday.

![% of centres vs. length of Clinical Day](image)

**Figure 3** The length of working day in centres around the country. Approximately 60% of departments are running at least a 9 hour day with 40% running at least a 10 hour day.

Three departments routinely treat patients on a Saturday with a further 4 treating emergencies or Category 1 patients on Bank Holidays.

### 7.2 Linac Servicing and Quality Assurance

The quantity and distribution of linac servicing and QA tasks was analysed. On average, centres reported undertaking a total of almost 2250 hours of this type of activity per annum (including 1000 hours of daily checks). This included the following categories of work, expressed as a percentage of the total.
Figure 4. The breakdown of linac QA and servicing activities as a percentage of the overall time – average of 2250 hours per annum per centre.

This equates to an average, excluding daily checks, of approximately 250 hours per annum per linac (of which 160 hours fall within the standard week) though there is significant variation in the amount of time used per linac and consequently time per centre. There appears to be little correlation between the size of the department and the time used. The time used will depend upon both the complexity of the linacs and the treatment techniques being delivered.

Further analysis of the data returned indicates the following:

- 70% of monthly QA or in-house servicing takes place during the standard working week
- 10% of centres use weekends for elements of QA, and in-house servicing
- 60% of annual in-house servicing is performed during the standard working week with 40% being performed at weekends
• 75% of annual QA is performed during the standard working week

With regard to manufacturer servicing, the following observations can be made:

• In centres where manufacturer monthly servicing is performed, this is done on weekdays only, with 80% of this being done in standard hours.

• 85% of manufacturers’ annual servicing is performed in standard hours on weekdays

Additional Planned Preventative Maintenance (PPM) including manufacturer Preventative Maintenance Inspections is performed largely Mon-Fri (75%) with 25% at the weekends.

7.3 Patient-Specific Quality Assurance and Treatment Plan Validation

Patient-specific QA measurements for IMRT, VMAT and stereotactic patients are commonly required prior to treatment to verify individual patients’ treatment plans. These require linac and Physics staff time to perform and then to analyse. The proportion of plans verified varies between departments, with some measuring all plans, while others QA a limited number for a new treatment site, then use a combination of sampling and software based methods for verification. Future software products may well reduce the proportion of actual plans required to be measured, however introduction and development of innovative techniques will continue to require validation by patient-specific QA measurement. Extending the day for clinical treatments has a double impact; both reducing linac availability during normal working hours for plan validation due to increased patient workload, as well as increasing the number of plans required to be validated, with the national drive for ever increasing amounts of advanced radiotherapy.

70% of centres are required to undertake patient-specific QA outside the standard working day

Approximately 65% of IMRT patients and 50% of SRS/SABR patients have routine measurements taking approximately 20-25 minutes/patient on the linac, followed by analysis of the results. Batching of patient QA plans in a measurement session can assist in reducing the overall time/patient on the linac

The average delivery rate for IMRT over the period of the survey (October-December 2013) was 27% of all radical patients

IMRT QA measurements dominate the patient-specific QA time required, typically > 3-4 hours/week for the larger (>5 linac) departments

It is estimated that the average department spends around 200 hours per annum on patient-specific QA.
7.4 Additional Linac-Based Activities

In addition to the Linac QA, servicing and patient-specific QA activities detailed above, on average approximately 1500 hours are required per centre (or approximately 300 hours per linac) per annum. This time is spent on a variety of essential linac-based activities, such as commissioning of new dosimetric equipment, system upgrades and testing, service developmental work, clinical trials work, R&D, training, dosimetric inter-comparisons and computer system backups. The relative distribution of activities is illustrated in Figure 5 below. Over 50% of these additional tasks are performed outside the standard day, with 28% being performed before 09:00hrs or after 17:00hrs and 24% being performed on weekends. It is therefore clear that time needs to be protected in any extended hours treatment regime to allow these activities to continue.

![Pie chart](image)

**Figure 5.** The breakdown of additional linac based activities as a percentage of the overall time – average of 1500 hours per annum per centre.

7.5 Availability of Service Efficiency Machines and/or Decant Bunkers

The NRAG report [1] recommended that centres should be in the position of having a SEM to minimise the impact of QA on capacity and a spare/decant bunker to maintain capacity through a linac replacement programme.
However, the current survey indicates that there is a significant under-provision of both resources.

- Only 6 of the 32 responding centres (19%) have a service efficiency machine
- Only 16 of the 32 (50%) have a spare decant bunker.

Lack of a SEM will lead to difficulties as demand increases; lack of a spare bunker has a significant impact as overall treatment capacity is reduced when one linac is removed to be replaced, often taking 6-12 months. Whilst one might expect this to have a major impact in the smaller departments with 2-3 linacs, the impact cannot be underestimated in large departments either, particularly when extended days are already being run prior to beginning a linac replacement.

The survey also indicated that those departments with a SEM tended to run over a significantly ($P<0.05$) longer average clinical day (10.2 hours) compared to the average for those without (9.2 hours) with the standard deviation in the mean in each case of approximately 1.0 hour.

In addition to the above benefit, having a SEM enables a centre to maintain capacity while QA is being performed and also allows it to cope better with fluctuations in activity and in breakdown scenarios enabling patients to continue to receive timely treatment.

### 7.6 Availability of Medical Physics Expert Advice

There seems little consensus surrounding how formalised the role of the Medical Physics Expert is in respect of extended day working. No doubt this is dependent upon what cover is being provided, the number of linacs being run, what category and complexity of patients are being treated and whether advice for treatment from an MPE is, in reality, routinely required.

7/32 (22%) of centres indicated they had either on site or formal phone access to an MPE during extended operational hours.

25/32 (78%) of centres reported having either an informal telephone contact or no guaranteed access to MPE advice.

Given the above information it will be important to determine safe staffing levels and availability of appropriate levels of experience of staff supporting extended day working.

### 7.7 Summary

From the data gathered in this survey it is clear that in a majority of centres Radiotherapy Physics services are already engaged in considerable amounts of work outside of the standard 09:00-17:00 day. The breakdown of Physics activities in terms of hours spent in the average centre is as follows:

- 1250 hours linac servicing and QA, excluding daily QA ($\approx$250 hours per linac)
• 200 hours patient-specific QA
• 1500 hours additional linac-based activities (≈300 hours per linac)

There is significant variation in the data between departments nationally and as such it is not easy to prove significant correlation of the figures as a function of departmental size. However these figures are consistent with those published following the last survey in 2008 [10] and [11].

Thus the total of approximately 3000 hours per annum is equivalent to the order of a full year’s linac-based activity over and above the patient treatment activity in the centre. Therefore it is vital that this time remains available if further extended hours regimes are required. Full availability of service efficiency machines and decant bunkers across the country will clearly need to be ensured to allow the provision of the necessary Radiotherapy Physics service under these circumstances.

**Summary of Key Points**

- Over 50% of Radiotherapy Centres are already providing a clinical service outside the hours of 09.00hrs – 17.00hrs Monday to Friday.

- Relatively few radiotherapy centres currently work at weekends

- Nationally an average of almost 250 hours of linac maintenance and QA is undertaken per linac per annum (excluding daily checks). There is a large national variation between centres which is dependent on the number of linacs, complexity of equipment and advanced treatment techniques.

- Manufacturers’ planned maintenance continues to be undertaken during Monday to Friday. To increase clinical activity this activity would need to be moved to either overnight or the week end.

- Validation of complex plans by measurement on a linac will continue to be required during the introduction of new treatment techniques and for routine complex treatments. Extending the clinical hours of work impacts significantly on the access arrangements for these measurements unless they are scheduled during the clinical day.

- Access to linacs is required for a range of activities essential to maintain the radiotherapy service, such as commissioning of new dosimetric equipment, system upgrades and testing, service developmental work, clinical trials work, R&D, training, dosimetric inter-comparisons and computer system backups. The time required is in the region of 300 hours per annum per linac.

- The total time required for linac maintenance, QA, and activities essential to maintain the radiotherapy service justify the requirement for centres to have both a service efficiency machine and a decant bunker to maintain the clinical service as stated in the NRAG report.
8 The Impact of Extended Hours on Different Size Radiotherapy Centres

The size and configuration of a department is most likely to influence the decisions made regarding the model used and issues affecting extended hours working. For this reason several different sized radiotherapy departments were contacted to ascertain their experiences with regards to extending the clinical day. A summary of issues raised is provided in this section.

8.1 Small Radiotherapy Centre (3 or fewer linacs)

The radiotherapy departments of the Royal United Hospital (Bath) and Peterborough City Hospital are both currently independent two linac centres. With a small department the provision of a service efficiency linac is almost impossible.

If a large proportion of non-clinical activities required to deliver a safe clinical service are moved outside clinical hours then this has a considerable impact as they are left with only a skeleton physics and in particular engineering staffing during core clinical hours. However, both departments questioned have limited the impact of this by running one linac for extended hours compared to the other, allowing QA and PM activities to take place during clinical hours. This is less of an issue for small satellite centres, for example, the Christie satellite departments, as there is a larger pool of staff at the main site which can be called upon to provide cover if required. In order for this model to work efficiently in a small department it is necessary to have matched machines to give some flexibility in scheduling patients. Even if this is the case there could potentially be difficulties in providing a safe service when the linacs are due for replacement as one may require back-up planning for patient treatments. Additionally, running one linac for extended hours with full ancillary services for patients could prove to be very expensive.

Any kind of major upgrade to the RMS, linac or associated imaging equipment which cannot be scheduled over the weekend can be a major problem due to having only one/two linacs to treat two/three linacs’ workload. For example, Peterborough recently had an upgrade to a linac that was scheduled over four working days which meant the second linac was required to treat clinically from 07:30hrs to 22:00hrs over this time. Any kind of downtime on the clinical linac or extended hours working during this upgrade period would have made the clinical day unfeasibly long and required the cancellation of some patient treatments.

Peterborough currently carries out large amounts of PM and more extended QA on linacs during the weekends, if any kind of six or seven day working is implemented then this may impact on such a model of working depending on how extensive a clinical service is offered.

8.2 Medium Radiotherapy Centre (between 4 – 6 linacs)

Oxford University Hospital Radiotherapy department currently has six linacs, one of which is a service efficiency machine. The department has a long history of some form of extended hours working on an intermittent basis. Over the years several specific agreements have
been negotiated between the department and the Trust in terms of the amount of extended hours working required, including staffing level needed (numbers and experience) and payment provisions.

The departments’ normal treating hours are 08:00hrs to 18:30hrs on weekdays. Recently, the department has found it difficult to maintain a service efficiency machine due to capacity issues and having major upgrades on linacs which require extensive periods of commissioning. This has meant that QA and PM activities have had to take place in the evenings. For these reasons since June 2013 the department has implemented weekend working in the form of two linacs treating for four hours on both Saturday and Sundays (staff preference was to have two linacs treating over a shorter day rather one linac treating a full day) rather than further extending the weekday treating hours. In the departments experience further extending the weekday clinical hours would require a shift based working pattern as worked at Norwich (see below) which is more difficult to staff at Oxford rather than the current pattern worked at the centre (four day working with rolling day off).

The department only treats reasonably fit patients during the weekend and does not start any new patients, therefore reducing the number of ancillary support staff required. Physics and engineering cover during the weekends is provided by one Medical Physics Expert, one engineer and two technologists, who are able to carry out QA, PM and development work on the non-clinical linacs.

Norwich Radiotherapy department is slightly smaller than Oxford and currently has four linacs, one of which is a service efficiency machine. The department has been working extended hours routinely since 2010, treating up until 20:00hrs in the evenings. One engineer and one clinical scientist (any grade) participate on a late shift rota with staff given clear work procedures in the event of a problem scenario. Although initially the department insisted no new patients were planned to start treatments in the evening, they have had to relax this requirement as it has become increasingly difficult to maintain due to capacity pressures.

At the centre radiographers work a four day week with a number of clinical scientists also working a four day week. For clinical scientists working four days a week one of the days is incorporated as a ‘late shift’ day, i.e., 12hr working day. The departments experience with such a system of working has been positive as the rota has been able to accommodate flexibility for staff in a number of ways, for example, those who want a fixed day working late or a fixed day off. The radiographers four day week working pattern consists of working either an early or a late shift with a rolling day off. This means that there are more staff present in the middle of the day which is arguably less efficient. When there are further capacity pressures at the centre, the radiographers work overtime on a Saturday by voluntary agreement, with an engineer usually present for support. This is clearly unsustainable as a long term option.

Due to the availability of a SEM most PM and QA is carried out during the core clinical hours, with some work carried out during the late shift, however, the department’s experience of this is that the amount of work carried out in the evenings is very dependent on the knowledge and experience of the staff covering the shift and is not guaranteed. The routine QA schedule has been revised so that all annual and three monthly checks are
spread over the monthly QA slots thus making scheduling more efficient on an on-going basis.

The department is about to expand to five linacs and it is anticipated that three machines will work until 20:00hrs on a regular basis whilst maintaining the service efficiency machine. There have been some occasions at the department, when one machine has been on service and another has broken down at the same time, however, it is very rare at the centre for a patient’s treatment to be cancelled completely on any particular day even in such a scenario.

8.3 Large Radiotherapy Centre (7 or more linacs)

Mount Vernon Cancer Centre is an eight linac cancer centre which currently works extended hours from 08:00hrs to 20:00hrs during the weekdays (CHART patients treated until 21:00hrs). The centre has recently implemented a rota for the presence of a MPE on site, having previously relied on MPE phone cover. This was due to experiencing some issues which staff found difficult to solve over the phone and the fact that specific staff were receiving the majority of phone calls.

The centre has a service efficiency machine and additionally the physics team has been able to negotiate pairing of linacs with the radiographers such that one works an extended clinical day whereas the other finishes sufficiently early, nominally 17:00hrs, to allow for patient-specific QA to take place for complex treatments. Due to the availability of a SEM the majority of the PM and QA work takes place during the clinical day at this centre, cross calibrations and most development work is also carried out during the clinical day.

The experience of this centre is that corrective maintenance suffers due to extended hours working as most work needs to be carried out late in the evenings when engineering staff is limited and not all engineers can carry out all maintenance tasks. The centre limits specific treatment techniques to certain linacs; this reduces the overall amount of QA required within the department, for example electron beams are only used clinically on three of the eight linacs as a result electron QA is only carried out on those three linacs. This results in a reduction in QA time of around 5-10 hours per month per linac.

The current experience of extended hours working of the Christie radiotherapy department, which has twelve linacs at the main Withington site and additionally two satellite centres with two linacs each, is different to Mount Vernon Cancer Centre. This is mainly due to only having a partial service efficiency linac in place at the main site which is undergoing a rolling linac replacement programme and additionally having a mixture of linac types. The Christie department currently works from 08:00hrs through to a nominal 18:00hrs finish, however, unlike Mount Vernon some linacs are not planned to finish early for patient-specific QA for complex treatments or corrective maintenance. From a staffing perspective the department operates a late MPE rota in the same way as Mount Vernon; however, only one MPE is required to cover all 3 of the Christie sites as all the patient related information is available on any of the sites.

The Christie carries out a large number of VMAT/IMRT treatments (currently 35%). This presents a significant challenge as patient-specific QA is carried out in the evenings after
clinical treatments have finished. Well matched machine plans are batched so that plan verification does not need to occur on the patient treatment machine, thus allowing more efficient plan verification, however on occasions when the clinical day is extended staff have carried out plan verifications very late into the evenings, i.e., beyond 21:00. It is worth noting that as departments across the country aim to increase their numbers of VMAT/IMRT treatments this will present significant scheduling challenges and innovative patterns of working will need to be developed to allow these patients treatments to receive the required QA. Here the Mount Vernon model of paired machines could be utilised to advantage.

Due to the availability of a partial SEM at the Christie in the afternoons most servicing is carried out during this time finishing at around 19:00hrs. However, as some linacs’ clinical workload cannot be transferred to the service efficiency linac without dual plans, due to differences in linac manufacturer/treatment head characteristics, these machines are serviced by spreading the workload to the other matched machines, thus making the clinical day on those linacs longer. Smaller items of machine QA are carried out as part of daily run-up as the standard run-up time has been driven down to approximately 30 minutes, with other larger QA items completed in the evenings and weekends. Additionally, corrective maintenance is carried by a pool of engineers who are on a late rota until 19:00hrs (or later depending on clinical day). Any service development work and cross calibrations are done outside clinical hours. In such a large department with numerous chambers and types of linacs, the annual cross calibration round can be an onerous task that can take 4-6 weeks, if not longer, to complete.

The Christie physics and engineering department has a minimum staffing level policy in place which ensures that staffing levels are not reduced to a level which may impact on the clinical service during normal treating hours due to the amount of evening/weekend work carried out. Staff are not allowed to take lieu time if staffing levels are to fall below that required, additionally, overtime is available for staff below Agenda for Change (AfC) band 8. The Christie model only really works if linacs are finishing sufficiently early. Any kind of further extended hours working could lead to the physics and engineering staff being pushed to regularly work very late in the evenings and weekends and therefore this may require additional staffing resources and unsocial hour’s payment under NHS Agenda for Change.

One of the main points raised by the radiotherapy department of St James’s Institute of Oncology (Leeds), which is a ten linac radiotherapy centre, is Private Finance Initiative (PFI) contractual hours. The department is a PFI build and currently has a good agreement allowing some amount of extended hours working over six days a week if necessary. Another such PFI build department is the radiotherapy department at the Northern Centre for Cancer Care (Newcastle). The equipment within this department was purchased by the NHS Foundation Trust, which has added clauses in the PFI contract such that the clinical service cannot be affected by the PFI Company. However, flexibility for extended hours working for some PFI build departments (of any size) can be very limiting. For example, although Norwich radiotherapy department is not restricted in terms of linac use, any use outside core hours is at the NHS Trust’s risk. If a linac breaks down outside core hours then the PFI Company is not liable for any penalties that would normally be imposed for a breakdown during core hours which would result in loss of patient appointments. Another such example is the radiotherapy department at the Beacon Centre (Taunton), where any use of the linacs outside core hours of 09.00-17.00 attracts an additional cost to the NHS.
trust. Additionally, engineering support for breakdowns on the linacs cannot be provided outside core hours by the PFI Company, so any linac breakdown is dealt with the following day. Any extended hours working cannot therefore make use of all of the linacs at the department as a breakdown would impact on the following day. Changes required to PFI contracts can prove to be very costly and time consuming to make.

Summary of Key Points

- Extending clinical hours in smaller departments can significantly impact staffing during core hours, especially if all servicing and QA is carried out outside clinical hours.

- The provision of a service efficiency linac, which is impossible in a small department, can help limit the amount of physics and engineering work that is required to be carried out outside clinical hours.

- Pairing of linacs such that one works an extended clinical day whereas the other finishes sufficiently early can also aid with the reduction of physics and engineering work that is required to be carried out outside clinical hours.

- Limiting specific treatment techniques to a small number of linacs in the department reduces the overall amount of QA required within the department.

- PFI contracts vary considerably and can limit the flexibility of a department to operate an extended hours clinical service. Changes required to PFI contracts can prove to be very costly and time consuming to make.
References


https://www.gov.uk/government/publications/tier-2-shortage-occupation-list-from-6-april-2013

http://www.rcr.ac.uk/docs/oncology/pdf/BFCO%2813%291_RT_capacity.pdf.


## Appendix A: IPEM WORKING PARTY - Impact of extended hours working on Radiotherapy Physics

<table>
<thead>
<tr>
<th>Number of Clinical Linacs</th>
<th>Centre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service efficiency machine(s) available?</td>
<td>y or n?</td>
</tr>
<tr>
<td>Spare/Decant Bunker(s)</td>
<td>y or n?</td>
</tr>
</tbody>
</table>

### Monday-Friday Sat Sun

<table>
<thead>
<tr>
<th>Usual Clinical Day</th>
<th>e.g. 8:00-17:30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total hours worked per day (summed over all clinical linacs)</td>
<td>Please note on right any differentiation between actual clinical hrs and QA time</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Is any staffing resource funded for extended hrs?</th>
<th>e.g. X WTE ClinSci, Y WTE Engineer etc</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do you provide MPE support ‘out of hours’?</td>
<td>e.g. formal on-call / informal via telephone / MPE on site at all operational times</td>
</tr>
</tbody>
</table>

### Servicing/QA

*If multiple patterns of servicing/QA are in use for different groups of machines, please record under multiple Machine Types*

### Machine Type 1.

<table>
<thead>
<tr>
<th>No. of machines following this</th>
<th>Performed by</th>
<th>(Tick all that apply)</th>
</tr>
</thead>
</table>
### Frequency of Testing

- **Daily checks (per day)**
- **Weekly checks (per week)**
- **Monthly QC checks (per calendar month)**
- **Monthly Servicing (in-house) (per calendar month)**
- **Monthly Servicing (company) (per calendar month)**
- **Annual Servicing (in-house) - per annum**
- **Annual Servicing/PMI (company) - per annum**
- **Annual QA - per annum**
- **Other intervals** (Note task and interval as required)

### Specific Testing Schedule

- **Monday-Friday**
  - **Before 9am**
  - **9am-5pm**
  - **After 5pm**
  - **Any time**

### Person Performed

- **Radiographer**
- **Clinical Scientist**
- **Technologist/Dosimetrist**
- **Engineers**
- **External FSE**

### Machine Type

- **Machine Type 2.**

### No. of Machines Following This Pattern

<table>
<thead>
<tr>
<th>Monday-Friday</th>
<th>Sat</th>
<th>Sun</th>
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<tbody>
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</tbody>
</table>

- **Performed by** (Tick all that apply)
**All values in hours/machine**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Monday-Friday</th>
<th>Sat</th>
<th>Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily checks (per day)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekly checks (per week)</td>
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<tr>
<td>Monthly QC checks (per calendar month)</td>
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<tr>
<td>Monthly Servicing (in-house) (per calendar month)</td>
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<td>Monthly Servicing (company) (per calendar month)</td>
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<tr>
<td>Annual Servicing (in-house) - per annum</td>
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<tr>
<td>Annual Servicing/PMI (company) - per annum</td>
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<tr>
<td>Annual QA - per annum</td>
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<tr>
<td>Other intervals (Note task and interval as required)</td>
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*If more than two patterns of servicing/QA are in use, please copy the above cells as necessary*

In addition we are seeking information on when work requiring Linac Access is performed.
### Additional Linac Access hours

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Monday-Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td>before 9am</td>
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<tr>
<td>9am-5pm</td>
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<tr>
<td>after 5pm</td>
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</table>

**Average Time (mins) / patient for:**

- **IMRT/VMAT patient-specific QA measurements**
- **% of IMRT patients having patient-specific QA measurements**
- **% of patients having IMRT (Average Oct-Dec)**

**Average Time (mins) / patient for:**

- **SRS patient specific QA measurements**
- **% of SRS patients having patient-specific QA measurements**

- **SBRT/SABR patient specific QA measurements**
- **% of SBRT/SABR patients having patient-specific QA measurements**

- **Any other patient-specific QA measurements (not covered above)**

**Total Hours for 2013**

- **In-house Upgrades and post upgrade commissioning and testing**
<table>
<thead>
<tr>
<th>Activity</th>
<th>Manufacturer upgrades and post upgrade acceptance and testing</th>
<th>Clinical Scientist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service / technique developments</td>
<td></td>
<td>Technologist/Dosimetrist</td>
</tr>
<tr>
<td>Commissioning new equipment</td>
<td></td>
<td>Engineers</td>
</tr>
<tr>
<td>Annual Intercomparisons</td>
<td></td>
<td>External FSE</td>
</tr>
<tr>
<td>Maintenance e.g. database backups etc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical Trial work / R&amp;D</td>
<td></td>
<td></td>
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<tr>
<td>Training</td>
<td></td>
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</tr>
<tr>
<td>Audits - e.g. interdepartmental, national, trials, linac</td>
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</tr>
<tr>
<td>Other:- Please add as appropriate</td>
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</tbody>
</table>

**General Notes/Comments/Feedback**