

Radiology business intelligence for service planning and workforce modelling

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Introduction

The purpose of this guidance

There are a huge number of vacancies for radiologists in the NHS. However, unless there is statistical data that articulates this, radiologists are unlikely to be taken seriously when they complain about being overworked and stressed. The purpose of this document is to enable technology companies, especially radiology information system (RIS) providers, to improve data presentation for radiologists to articulate. Access to better information will enable radiologists to justify their arguments for funding for radiologist posts and increased recruitment.

This document is not intended as a tool to measure individual performance. Radiologists are involved in many non-measurable activities, including multidisciplinary team meetings (MDTMs), teaching and training, patient consultation, governance, service development and so on. These activities cannot be captured via RIS data analysis, which makes this document's use as an individual performance evaluation tool meaningless. For a typical diagnostic radiologist only 40% of their total job-planned time may be spent on reporting, and 10–20% on procedures. An interventional radiologist may spend 30% of their job-planned time on procedures and 20% on reporting. Overall only about 60% of a typical radiologist's job-planned time may be spent on measurable activities. It is essential that radiologists have full transparency of business intelligence (BI) units (for acquisition, vetting, supervision and reporting) used in the database, and also understand how the RIS measures capacity from their job-planned sessions.

Why data transparency?

It is widely recognised that data transparency in business is moving from 'need to know' to 'complete transparency of metrics'. Studies show that when team members feel informed and involved, they put more effort into work and are more productive.¹ If employees understand their employer's metrics, they will test solutions, generate better ideas and solve problems more effectively with managers. Transparent data and metrics boost morale and result in teams pulling together. Demand, activity, capacity and turnaround times are the key data items in radiology. Understanding these will empower radiologists and radiology departments to overcome the challenges they face, not least the 'workforce crisis'.

1. Real-time business intelligence

Business intelligence

Business intelligence (BI) is a tool that can map radiology workflow. Real-time analysis enables departments to monitor demand, activity and waiting times against local and national benchmarks, in granular detail. Most existing RIS (with or without plug-ins) collect periodic, retrospective data that is already historic information. Modern RIS should enable frontline staff, in every radiology department, to produce and readily analyse real-time data, identify bottlenecks and backlogs and generate potential solutions. All radiologists must be familiar with simple BI concepts and able to calculate demand and capacity mismatches in service when required.

Radiology metrics

There are three main measurable activities in radiology departments:

1. **Vetting and protocoling** – the process of accepting or rejecting a referral to a radiology department (and defining or editing a protocol where relevant).
2. **Image acquisition and intervention** – the act of imaging a patient using an X-ray machine, computed tomography (CT) scanner, ultrasound (US) machine or similar. These generally require radiographers, but radiologists perform US and interventional procedures.
3. **Reporting** – where a radiologist (or reporting radiographer) produces the clinical report to accompany an image (generally requires a picture archiving and communication system [PACS] workstation).

Derived radiology metrics

1. **Demand, activity and backlogs** – relates to vetting, acquisition and reporting
2. **Waiting and turnaround times** – relates to vetting, acquisition and reporting
3. **Machine/room capacity** – relates to machine and room resources, including opening and closing times (scheduling). Wasted capacity relates to breakdowns and non-attenders.

Note: Human resource (radiologist and radiographer) capacity will require analysis of job-plans and timetables and cannot be extracted from RIS data.

RIS data

1. **Directly recorded data** – this is data directly input to or collected by a RIS database from the order message. It is thus readily available from the database itself. Examples of directly recorded data with every transaction are patient ID, date and time (DT) stamps, referrer ID, examination code, clinical priority, patient location at referral, examination room, staff involved in transactions and so on.
2. **Referenced data (from RIS reference/look-up tables)** – RIS will use display data via look-up tables which link to the recorded data, for example, job role of a referrer, employer of an operator, type of referring location and so on.
3. **Derived data (using calculations based on definitions)** – this may require external algorithms (plug-ins) to produce data items such as capacity, backlog, activity and so on. Some RIS are better at producing derived data than others.

RIS reference/look-up table data

Reference or look-up tables are used to extract meaningful data from computer-recorded data in the form of codes and unique IDs. A good look-up table within RIS is essential for meaningful data presentation for clinical workflow and also for meaningful BI. Consistency in the construction of look-up tables will enable comparison.

1. Patient data (updated by HL7 ADT feeds from the patient administration system [PAS])

These are linked to the unique PAS ID of the patient.

- a. Unique PAS ID
- b. NHS number (unique national ID)
- c. Name
- d. Date of birth (DOB)
- e. Sex
- f. Address
- g. Registered general practitioner (GP)
- h. Registered GP surgery

2. Staff (RIS users) and referrer data (reporter, referrer, operator, vetter and supervisor)

Updated manually by system administrator or by HL7 master file notification (MFN) messaging. These are linked to the unique ID of the staff member or referrer.

- a. Unique national ID (General Medical Council [GMC] number, General Dental Council [GDC], Health Care Professions Council [HCPC] code and so on)
- b. Full name
- c. Job role (as per NHS Data Dictionary)²
- d. Main specialty (for medical qualifications from GMC website using NHS Data Dictionary)
- e. Employing organisation (NHS code for NHS organisation, NHS hospital or GP surgery)

3. Location (referring location and radiology examination room)

Updated manually by system administrator or by HL7 MFN messaging. This is linked to the unique ID of the location.

- a. Unique ID
- b. Name
- c. Location type for referring locations – emergency department, GP, outpatient, inpatient, other
- d. Hospital site
- e. Organisation – NHS organisation code/ID and name – hospital, GP surgery and so on
- f. Waiting room ID linked to examination room (for examination rooms)
- g. Kiosk ID linked to examination room (for examination rooms)

4. Radiology examination reference/look-up table

The RIS system administrator usually updates this manually.

- a. RIS examination code (as there may be local codes)
- b. National interim clinical imaging procedure (NICIP) code equivalent (this should be transmitted in the outbound HL7 message to other NHS organisations)
- c. SNOMED CT translation code
- d. Examination description (clinically meaningful description of the examination)
- e. Modality type (digital imaging and communications in medicine [DICOM])
- f. Examination type – diagnostic, interventional or treatment
- g. Acquisition BI unit (local)
- h. Reporting BI unit (local)
- i. Vetting BI unit (local)
- j. Addendum reporting BI unit (local)
- k. Supervision BI unit (local)
- l. Tariff for acquisition (national)
- m. Tariff for reporting (national)
- n. Outsourced cost for acquisition (local)
- o. Outsourced cost for reporting (local)
- p. Acquisition benchmarking unit (national)
- q. Reporting benchmarking unit (national)
- r. Vetting benchmarking unit (national)
- s. Addendum reporting benchmarking unit (national)
- t. Supervision benchmarking unit (national)

2. Accuracy of business intelligence

Good BI results depend on the accuracy of directly recorded data in the first place. However, accuracy and completeness of the reference table is equally important. Accurate derived data relies on accuracy of the application of data definitions and also accurate recording of data.

Radiologists must be able to visualise directly recorded, referenced and derived data within the RIS workflow to prioritise tasks and improve workflow.

This document explains how departmental staff and radiologists can interpret the BI information on the RIS to analyse the demand for their services, in the form of:

1. Scanners
2. Radiographer staffing
3. Radiologist staffing

The ability of RIS to inform radiologists, radiographers and departmental managers via BI of demand for their services enables numbers of scanners and human resources to be matched with capacity.

Workflow status and date and time stamp relationship

Workflow status is a key concept in real-time BI. Waiting and turnaround time (TAT) analysis requires consistent definitions and accurate recording of DT stamps. Demand, activity and backlog analysis requires accurate knowledge of current workflow status within RIS for each examination.

Workflow statuses in RIS

Statuses must include:

1. Requested or new order/request
 2. In-vetting (waiting for vetting to be done)
 3. Vetted/approved (waiting to be scheduled)
 4. Scheduled (appointment given)
 5. Patient arrived (patient in department)
 6. Examination started (patient in room)
 7. Held (request held – waiting for additional information and so on)
Note: An examination once released from hold should go into vetted status or requested status.
 8. Examination cancelled
 9. Acquisition completed (examination completed)
 10. Report dictated (not relevant when voice recognition is used)
 11. Report transcribed (not relevant when voice recognition is used)
 12. Primary report authorised
-

Date and time stamps

All RIS must record the following DT stamps when there is a change in workflow status. Consistency of definitions is essential for comparative data analysis and benchmarking.

1. Requested DT – when the referrer requests the examination (on Ordercomms or paper)
2. Request received DT – when the request arrives in the department (a and b are identical for electronic requests)
3. Sent for vetting DT (first vetting) – not mandatory field
4. Vetted DT (final vetting) – not mandatory field
5. Scheduled DT – final appointment booked
6. Acquisition waiting time start DT – this should default to request date but could be changed with a reason provided – for example, does not attend (DNA), patient re-schedules (planned examinations will be excluded from acquisition waiting time stats)
7. Patient arrived in department DT
8. Examination started or patient arrived in room DT
9. Examination completed DT (when examination is completed by radiographer on RIS and sent for reporting – this should not be confused with date automatically populated by the machines/modalities when images were acquired)
10. Primary report authorised DT
11. Cancelled DT (when an examination is cancelled)
12. Hold DT – when examination was put on hold first time
13. Released (from hold) DT (when the examination was released from held status – final time)
14. Last image DT (acquired on the modality) – this would generally need to be extracted from PACS

User-editable time stamps

There are only four dates and times that should be editable by users:

1. Scheduled DT of the appointment – as this is often changed
2. Acquisition waiting time start DT (this is changed by staff as per data definitions)
3. Request DT (should be editable for paper referrals only)
4. Request received DT (should be editable for paper referrals)

Other DT stamps should be logged by the computer and based on status changes made by RIS. This should not be editable by the users as it skews data for the next step and makes it difficult to make proper business decisions. For example, manipulation of examination completion DT would skew the data and make reporting TAT look poor.

BI units

These are units of time used for local scheduling of radiology activities: image acquisition, reporting, supervision and vetting. BI units are **based on an average time for an activity (acquisition, reporting, vetting, supervision and addendum reporting)**. BI units in radiology are defined in minutes. The following BI units are essential if the RIS is to provide a level of detail useful for departmental planning:

1. Image acquisition BI units
2. Primary report BI units
3. Addendum (additional) reports BI units
4. Supervision BI units
5. Vetting BI units

BI units are the mainstay of all demand, capacity and activity metrics.

Each examination code within RIS must be linked to a BI unit of acquisition in minutes, a BI unit for a primary report in minutes, a BI unit for addendum reports, a BI unit for supervision in minutes and a BI unit for vetting. For example, if a CT head has a BI unit of ten minutes for acquisition, then six CT heads require 60 minutes of capacity on a scanner. Similarly, if the BI unit for the primary report for a CT head is proposed at ten minutes, then 60 minutes of reporting capacity is required for six scans. If a BI unit of six minutes is applied for addendum or supervision, then six minutes of activity should be added every time a report has an addendum issued or a supervisor has been involved in the reporting.

Image acquisition BI units are defined locally and derived from staffing requirements and degrees of workflow automation. This is essential for scheduling examination room activity.

Reporting BI units should also be agreed locally, and depends on the degree of workflow automation, the speed of information technology (IT) systems, human factors and disturbances while reporting.

Guidance from The Royal College of Radiologists on reporting BI units can be found on page 6 of *Clinical radiology workload: guidance on radiologists' reporting figures*.³ This could be used as a default on RIS systems and then adjusted for individual examinations by local radiologists to allow for poor IT and admin support available to radiologists (support for failsafe alert communication and so on). Local BI units will allow for real-time demand and activity data analysis based on local circumstances. However, if there is a need for benchmarking and comparison of activity between different hospitals, national units (such as those in the RCR document) may also be used.

Purpose of BI units

It is important to understand that BI units are for matching local demand, activity and capacity and defining any deficit therein. Using them for other purposes is likely to be damaging and counter-productive.

Exceptions in US and interventional procedures

Some examinations such as US and interventional procedures may include producing a report during image acquisition. If the reporting is done in the same room as the acquisition and by the same person who performed the examination it makes sense to combine them with acquisition activity. (As such, reporting activity will be zero BI units of reporting time.) However, if acquisition and reporting are done by different individuals or in different rooms, it must be possible to separate them. Again, these will be local decisions based on local workflow.

Autoreports or computer-generated reports should be allocated with zero reporting BI units because no workforce capacity is needed to produce them.

Vetting BI units

Currently there is no national guidance or formal recognition of this work. Vetting is, however, a vital part of referral justification and demand control. As a starting point, RIS could allocate one minute per examination. This could later be adjusted by local radiographers and radiologists. Every time an examination is formally vetted a BI unit should be added as a vetting activity.

National benchmarking units

While BI units are essential for local demand and capacity analysis, national benchmarking units are essential for making comparisons of demand and capacity between organisations. However, prior to any benchmarking it is essential that all departments are consistent in counting activity. Use of national codes or national code equivalents are essential for proper benchmarking. It is also important that with every imaging activity counted for image acquisition there are images acquired (that is, there is use of human resource and machine resource in generation of the activity). If there are no images acquired with an image acquisition activity, there needs to be a justified reason. The number of images associated with the accession number should be extracted from PACS.

3. Examples of real-time business intelligence

This includes workflow status, BI units, demand, activity and backlogs (acquisition, vetting and reporting).

A CT head may be allocated a ten-minute BI unit for acquisition, a one-minute BI unit for vetting and ten-minute BI unit for reporting. This shows the relationship between RIS recorded data and derived data. The recorded data and derived data (demand, activity and backlog data) should be displayed together and visible to frontline radiologists on the RIS or RIS add-on software.

1. When a request for a CT head arrives within a department, it will create an acquisition demand for ten minutes, and an acquisition backlog of ten minutes at the same time. Workflow status is **requested**.
2. When it is sent for vetting it creates a vetting demand of one minute and a vetting backlog of one minute. Workflow status is **in-vetting**.
3. When vetting is completed, it creates a vetting activity of one minute, and the vetting backlog for that examination reverts to zero. Workflow status is **vetted**. However, if the examination is cancelled at the vetting stage, vetting activity remains at zero but acquisition backlog reverts to zero. Workflow status is **cancelled**.
4. When acquisition is completed, the acquisition backlog returns to zero and ten minutes of acquisition activity is recorded. Workflow status is **completed**. However, if the patient DNA, ten minutes are added as wasted capacity while acquisition backlog reverts to zero. Workflow status is **cancelled**.
5. Change to workflow status to **completed** also creates ten minutes of reporting demand and ten minutes of reporting backlog (exceptions are autoreport, intervention or US, which count as zero).
6. When reporting status changes to **completed**, ten minutes are added as reporting activity and reporting backlog changes from ten minutes back to zero. Workflow status is changed to **authorised**.

If each requested examination (with its unique accession number) has these real-time BI units applied, analysis for end users becomes transparent and straightforward

Acquisition demand, activity and backlog metrics

Acquisition demand

Using the previous example, a CT head will have an acquisition demand of ten minutes. When data filters are applied (see Appendix A for filterable data items), a **sum total of acquisition demand** for that list could be calculated and expressed in total minutes.

Acquisition activity

All radiology examinations or interventions which achieve a status of **completed** count towards 'acquisition activity'. Once a study (with its unique accession number) achieves **completed** status, RIS should display an equivalent 'acquisition activity' BI unit. When data filters (see Appendix A for filterable data items) are applied, a **sum total of acquisition activity** for that list could be calculated and expressed in total minutes.

Acquisition backlog

All examinations on a RIS waiting to be completed (that is, status of requested, in-vetting, vetted and scheduled) constitute an acquisition backlog. When a request for image

acquisition or intervention arrives within a RIS with a status 'requested', the RIS data should display the BI unit 'acquisition demand' as a data item for each examination; for example, a CT head will have an acquisition demand of ten minutes. Once the status is changed to completed or cancelled, the acquisition backlog reverts to zero minutes. This too should be a filterable data item for backlog analysis. (While demand for a time period will include all demand, whether completed or not, the backlog only shows outstanding demand.)

Reporting demand, activity and backlog metrics

Reporting demand

All radiology examinations with **completed** status that require reporting contribute to BI unit **reporting demand** (each with their own unique accession number).

Exceptions include:

- Autoreports (computer-generated, Ionising Radiation (Medical Exposure) Regulations [IRMER]-type reports)

US and interventional procedures would generate zero minutes for reporting demand if reporting is performed at the time of acquisition (and allowed for accordingly).

When data filters are applied, a **sum total of reporting demand** for that list could be calculated and expressed in total minutes.

Reporting activity

All radiology examinations that achieve **authorised** status should display the BI unit **report activity** as a data item for each examination.

Exceptions include:

- Autoreports
- US and interventional procedures, as above

When data filters are applied, a **sum total of reporting activity** for that list could be calculated and expressed in total minutes.

Reporting backlog

At any point in time, all examinations on a RIS that are not yet authorised contribute to the reporting backlog. For example, if the BI unit for a CT head is ten minutes and it achieves a **completed** status it will produce a reporting demand of ten minutes and also a backlog of ten minutes. When the status is changed to **authorised**, the report backlog should change back to zero. This should be a filterable data item for easy analysis of the total reporting backlog in minutes.

Vetting demand and activity metrics

Some departments do not vet any referrals; they simply perform every examination requested. However, vetting can be successful in reducing inappropriate demand on services. As such, many departments invest staff time in vetting (often radiographers). Examinations considered clinically inappropriate may be passed on to radiologists for a second opinion. Also, appointment-booking staff are often instructed to send certain subsets of examination for vetting depending on local rules (for example, all CTs and

magnetic resonance imaging (MRIs) must be vetted prior to scheduling, but not plain films), and this generates vetting demand. Alternatively, RIS rules may be applied to automatically send particular examinations for vetting.

Vetting demand

When an examination is sent for vetting it should be logged by the RIS as having generated a vetting demand, in minutes (one minute for most examinations). When filters are applied, a **sum total of vetting demand** could be calculated for the filtered list, in minutes.

Vetting activity

When vetting is completed, the RIS should display the vetting activity as a BI unit (for example, one minute) and the name of the vetter (whether the examination is approved or rejected). When data filters are applied, a **sum total of vetting activity** could be calculated for the filtered list, in minutes.

Vetting backlog

At any point all examinations waiting to be vetted (status: **in-vetting**) should be recorded as contributing to the vetting backlog. Each vetting backlog BI unit reverts to zero, when its status changes to **vetted**. This should be a filterable data item for easy analysis.

Cancellation metrics

All cancellation reasons must be identified by the status 'cancelled'.

1. Cancellation prior to scheduling (for example, cancelled by radiologist/radiographers at vetting or cancelled by patient) generates acquisition and vetting demand but does not waste capacity.
2. Cancellation due to DNA is **wasted capacity**.

Cancellations prior to scheduling

These cancellations contribute to acquisition demand but do not generate acquisition activity data. Exceptions are cancellation very close to the scheduled time, thus not giving enough time for reallocation.

Wasted capacity

DNAs utilise acquisition capacity but without generating activity. When an examination changes to **cancelled** status (with reason for cancellation: DNA), the RIS should display the BI unit for acquisition as 'wasted capacity'. When data filters are applied a **sum total of wasted capacity** could be calculated and expressed in minutes.

Wasted capacity from DNAs must be included during capacity planning exercises.

Waiting time (WT) and turnaround time (TAT) metrics

WT and TAT data help identify bottlenecks in the department. When a status change occurs it should be logged in the RIS database with a DT stamp. These status changes allow WT and TAT analyses to be performed.

Note: The difference between WT and TAT must be understood.

WT measures data in **real time**, that is both before and after an activity is completed.

TAT is measured **only after** an activity is completed, that is it is a retrospective data analysis.

Exclusions

Planned examinations need to be performed at a particular future date and therefore should be excluded from the WT and TAT datasets. If they are not excluded, they will skew the data. For example, follow-up imaging required in eight weeks, yearly surveillance scans and so on.

Autoreports are computer-generated reports and must be excluded from reporting WT and reporting TAT data analysis.

Waiting time definitions

Clear definitions of **WT start DT** and **WT end DT** are essential for data to be accurate and comparable.

Acquisition of waiting time data

Planned examinations should be excluded from image acquisition waiting time stats.

Acquisition WT **start** DT should default to the request date, but it should be possible for staff to change it (based on the below criteria as defined by NHS WT rules):

- Request DT (default)

OR

- DT of last appointment (criteria*) – if patient DNA or reschedules a reasonable appointment

OR

- DT when patient contacts for direct access referrals (criteria**)

*If the patient DNA and is given another appointment for the same request, or when the patient re-schedules a 'reasonable' appointment. (Reasonableness criteria is when a patient is offered at least two appointment dates and at least three weeks' notice. Letter via post is not considered 'reasonable' and in such cases request date will stand as the WT start date).

**Direct access referrals are where the patient is responsible for contacting the department to make an appointment (for example, walk in-service for plain X-rays will have arrived/in-department DT as the WT start DT).

Acquisition WT **end** DT:

- Today's DT (default) – for status requested, held, in-vetting or vetted

OR

- Fixed point when WT data is being collected – for status requested, held, in-vetting or vetted

OR

- Scheduled DT (for scheduled status)

OR

- Completed DT (for completed status and later)

Reporting waiting time

Autoreports should be excluded.

Report WT **start** DT from examination completed DT.

Reporting WT **end** DT:

- Today's DT (for statuses prior to primary report authorisation)

OR

- Fixed point when WT data is being collected (for statuses prior to primary report authorisation)

OR

- Primary report authorised DT (for authorised status)

In-department waiting time

- In-department WT **start** DT – patient arrival OR scheduled DT (whichever is later)
- In-department WT **end** DT – today's DT or a fixed point when data is collected or examination completed DT (for examination status completed or later)

Vetting waiting time

- Vetting WT **start** DT – when examination sent for vetting for the first time
- Vetting WT **end** DT – could be today's DT (or a fixed point when data is collected) or final vetting completed DT (for status vetted and later)

Turnaround time definitions

These are simpler to measure.

1. **Image acquisition TAT** is measured from requested DT to acquisition completion (planned examinations must be excluded from this dataset)
2. **Vetting TAT** is measured from sent for vetting DT (first time) to vetted DT (final time)
3. **Report TAT** is measured from acquisition completed DT to primary report authorised DT (autoreports must be excluded from this dataset)
4. **Diagnostic pathway TAT** is measured from requested DT to primary report authorisation DT

Each study with its unique accession number should have the above **WTs and TATs displayed for frontline staff**.

For a filtered list of data items, averages should be calculated for actual WT, TAT and also target WT.

Target turnaround times

The Royal College of Radiologists is a professional body that sets clinical and professional standards, not targets. However, it recognises that timely imaging and reports are essential for patient care. The NHS is responsible for staffing departments so that local and national targets are met. RIS databases that highlight shortfalls to radiologists and radiographers in real time are a useful tool in this regard.

At the time of writing, targets include:

1. Six-week wait target for elective (outpatient) diagnostics referrals (NHS Improvement)⁴
2. One hour for referrals from emergency departments (ED), 12 hours for urgent inpatients and 24 hours for non-urgent inpatients as per Clinical Standard 5 for 7-day services (NHS England)⁵

Radiology departments may subdivide this pathway locally into vetting, image acquisition and reporting.

Targets are derived data. RIS (with or without plug-ins) must be able to use recorded data to generate target data.

The following recorded data needs to be captured accurately for defining target TATs:

1. Modality
2. Clinical priority (urgent, two week wait (2WW), routine)
3. Referral location type (emergency department, inpatient, outpatient, GP, other)
4. Planned/unplanned examination (planned examinations have zero target for image acquisition TAT)
5. Autoreported – yes/no (autoreports have zero target for report TAT)

Target image acquisition time (acquisition)

Each examination should have a target waiting time for image acquisition (exception for planned examinations).

Algorithms used for calculating target DT for each examination would need to account for modality, clinical priority and referral location type.

Example local targets:

- Emergency department – 30 minutes (all priority)
- Inpatient – eight hours (all priorities)
- 2WW priority (excluding emergency department/inpatient) – one week
- Urgent priority – two weeks (excluding emergency department/inpatient)
- Routine priority (excluding emergency department and inpatient) – six weeks

Target reporting time (reporting)

Each examination should have a target waiting time for reporting (excluding autoreports).

Targets would need to account for modality, priority and referral types.

Example local targets:

- Emergency department – one hour (all priorities and CT modality)
- Inpatient – four hours (all priorities and CT and MRI modality)
- 2WW priority (excluding emergency department /inpatient) – one week
- Urgent priority – one week (excluding emergency department /inpatient)
- Emergency department and inpatient X-rays – two days
- Routine priority (excluding emergency department and inpatient) – three weeks

Target vetting time (vetting)

If a referral is sent for vetting it should generate vetting time and vetting demand.

Local targets will depend on modality, referral type and priority.

Target TATs and actual WTs should be visible side by side on the RIS (with or without plug-ins) for frontline staff to enable prioritisation of work.

RIS reporting worklists (filtering and sorting)

For radiologists to be able to support delivery of national or local targets, it is really important that they are able to filter and sort their reporting worklists according to the following data items.

1. Request DT – useful for national targets
2. Examination completed DT (by radiographer) – useful for local targets
3. Referral location type (source setting type as per the Diagnostic Imaging Dataset [DID]) – emergency department and inpatient X-rays, inpatient, outpatient, GP, other⁶
4. Clinical priority – urgent, 2WW (also called suspected cancer/soon) or routine
5. Main specialty of referrer – as per NHS Data Dictionary, to enable specialty-based reporting
6. Intended reporter (this could be named individuals or reporting pools)
7. Modality
8. Examination description
9. Actual WT
10. Target WT

Examples of reporting workflow prioritisation by filtering and sorting of RIS worklists:

- **Emergency duty/on-call radiologist** will deliver the emergency department and inpatient X-rays and inpatient reporting for CT and MRI. Emergency department and inpatient X-rays referrals and urgent inpatient referrals need to be prioritised over the routine inpatient CT and MRI referrals. The aim is to deliver emergency department and inpatient X-rays reports within one hour of referral.
- **Plain film reporting prioritisation** – in the following order: emergency department and inpatient X-rays, urgent inpatient, routine inpatient, 2WW elective, urgent elective and routine elective.

- **Elective (outpatient/GP/other) reporting from other modalities** – 2WW reporting will be prioritised over others. Urgent clinical priority will be done before routine.
- **Waiting list initiative work (insourced or outsourced)** – departments could set a ceiling, above which images are offered as waiting list initiative work.

RIS worklist for vetting (filtering and sorting)

For radiologists to be able to support delivery of national or local targets, they must be able to filter and sort their vetting worklists according to the following data items:

1. Request DT
2. First time sent for vetting DT
3. Referral location type (source setting type as per DID) – A&E, inpatient, outpatient, GP, other
4. Clinical priority – urgent, 2WW (suspected cancer/soon) or routine
5. Main specialty of referrer – as per NHS Data Dictionary
6. Planned/unplanned
7. Intended vetter (this could be named individuals or vetting pools)
8. Modality
9. Examination description

RIS worklist for scheduling, that is appointment worklist (filtering and sorting)

For radiology appointments clerks to be able to support delivery of national or local targets, they must be able to filter and sort their scheduling worklists according to the following data items:

1. Request DT
2. Referral location type (source setting type as per DID) – emergency department and inpatient X-rays, inpatient, outpatient, GP, other
3. Clinical priority – urgent, 2WW (suspected cancer/soon) or routine
4. Main specialty of referrer – as per NHS Data Dictionary
5. Planned/unplanned
6. Modality
7. Examination description

Waiting and turnaround time averages and exclusions

When WT metrics are applied to a list of filtered studies from Appendix A the WT output should be displayed as an average.

WT and TAT averages from a list of filtered data will allow staff to identify where bottlenecks exist within the department and compare this with other modalities.

Target waiting and turnaround averages

Each examination will have a true WT and a target WT. Comparison of filtered data will allow comparison of actual WT average with target WT average and allow for identification of bottlenecks.

Waiting time and turnaround time exclusions

Planned examinations should be excluded from acquisition WT and TAT data.

Autoreports should be excluded from report WT and TAT data.

The filtered list should be sortable to enable maximum waits to be identified.

Capacity calculation

There are three types of capacity.

1. Machine/room
2. Staff for acquisition (predominantly radiographers/radiologists perform US and intervention)
3. Staff for reporting

Staffed room/machine capacity is defined as time available on the scanner(s) for scheduling image acquisition.

Opening and closing time of scanner rooms will enable 'staffed machine acquisition capacity calculation'.

Opening and closing of scan rooms with identification of whether it is a regular (elective and emergency work) capacity or emergency session allows for crude capacity calculations.

Appendix B details the type of data items that need to be included within RIS to enable more intricate machine capacity calculations.

Acquisition capacity

This measures the total staffed scanner time available measured over a date range. Types of capacity may vary – for example, regular capacity and emergency capacity (such as at night).

Outstanding image acquisition capacity over a defined time period = (total capacity) minutes (already scheduled demand – that is status 'scheduled').

Lost capacity

This is the wasted capacity due to room closures due to servicing of machines during normal opening hours.

Reporting capacity

This is a measure of total reporting time available within job plans of all radiologists and reporting radiographers. Radiologists' job plans with defined reporting sessions are essential for capacity calculation. (US and interventional activity is included under acquisition capacity.) Reporting sessions may vary in length in different job plans.

Types of capacity will include regular, on-call/emergency and ad hoc/extra (for example backlog reporting).

Note: Where interruptions are likely during a reporting session, reporting capacity should be reduced proportionately (for example, an actual reporting session between 09:00 and 13:00 may have a reporting capacity of three hours to allow for this as well as fatigue, human factors and so on).

See Appendix B for data items that need to be collected for capacity calculation.

When reporting capacity is being logged in a RIS database – as per Appendix B – this data must be transparent and visible to all radiologists. Any inaccuracies in the methodology of calculation need to be agreed and corrected as a team. Transparency is key to accuracy of data.

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Appendix A. Radiology demand, activity and waiting time data – display for filtering and outputs (totals and averages)

Each radiology study performed with its unique accession number should have multiple data items linked to it (this will be a combination of directly **recorded** RIS data, reference table data and derived data). **All the data items below should be displayed as a single list of data items within the RIS (or an add-on function of the RIS)**. It must be possible to sort and filter these data items by radiologists, radiographers, other departmental staff and managers. It should be possible to apply both **inclusion and exclusion filters** to data items for analysis.

For a set of filtered data items the following outputs are required:

1. Total numbers of filtered items within the query
2. Average time for WT and TAT data items
3. Sum total for BI data items – for demand, activity and backlogs (expressed in total minutes/hours/days)
4. Sum total for cost data items
5. Sort the dataset for minimum and maximum values for WT and TAT

1. DT stamps (these are directly recorded data items on RIS)

- a. Requested DT – when the referrer requests the examination
- b. Request received date – when the request arrives in the department (a and b are identical for electronic requests)
- c. Sent for vetting DT (first time) – not mandatory field
- d. Vetted DT (final time) – not mandatory field
- e. Scheduled DT – when appointment was booked
- f. Acquisition WT start DT – this should default to request date but could be changed with a reason provided – for example, DNA, patient re-schedules (planned examinations will be excluded and will not have a WT start DT)
- g. Patient arrived in department DT
- h. Examination started/patient in room DT
- i. Examination completed DT (when image acquisition is completed by radiographer on the RIS)
- j. Primary report authorised DT
- k. Cancelled DT – when an examination is cancelled
- l. On-hold DT – when an examination is put on hold
- m. Released (from hold) DT – when the examination is released from held status

Inclusion or exclusion filters – it must be possible to filter for a DT range for a list.

2. Waiting time or turnaround time data items (these are derived data items using DT stamps and examination status)

WT measures real-time data, whereas TAT measures data retrospectively.

- a. Image acquisition WT – see previous paragraphs for definitions
- b. Reporting WT – see previous paragraphs for definitions
- c. Vetting WT – see previous paragraphs for definitions

- d. In-department WT – see previous paragraphs for definitions
- e. Image acquisition TAT – time from requested DT to completion DT (exclude planned examinations)
- f. Reporting TAT – time from examination completion DT to primary report DT (exclude autoreports)
- g. Vetting TAT – from sent to vetting DT to vetting completed DT

3. Target TAT data items (these are derived data items using clinical priority and referral location type)

- a. TAT – this is based on the rules taking into account priority and location type (emergency department, inpatient, outpatient, GP, other) and applied to the examination; planned examinations should be excluded from acquisition WT target
- b. Target report TAT – this is based on the rules taking into account priority and location type (emergency department, inpatient, outpatient, GP, other)
- c. Target vetting TAT – this is based on the rules taking into account priority and location type (emergency department, inpatient, outpatient, GP, other)

Inclusion or exclusion filters – it should be possible to filter for a WT duration range.

Output – average WT should be calculated when applied to a list query and displayed at the bottom of the list query.

4. Demand, activity and backlog data items (these are derived data items using examination status, BI units and national examination codes)

- a. Acquisition demand – the acquisition BI unit is displayed as soon as a referrer makes a request (for example, US abdo and pelvis = 15 minutes).
- b. Acquisition activity – acquisition BI unit in minutes – this will be logged as soon as the examination achieves 'completed' status.
- c. Primary report demand – BI unit in minutes (for example, X-ray = one minute 20 seconds, one body part CT/MRI = ten minutes, two or more body parts CT = 20 minutes, and so on). This is logged against the accession no. as soon as a study achieves 'completed' status.
- d. Primary report activity – reporting BI unit in minutes (for example, X-ray = one minute 20 seconds, one body part CT/MRI = ten minutes, two or more body parts CT = 20 minutes, and so on). This is logged against the accession no. as soon as a study achieves 'authorised' status.
- e. Addendum report BI unit – for example, six minutes for each addendum or report supervision from all modalities. The total addendum report BI units logged against the accession no. will depend on the number of addendum reports produced for the study.
- f. Supervised report activity BI unit – for example, six minutes for each report supervision. Supervised report BI units logged against the accession no. if a supervisor is logged against the report.
- g. Vetting demand BI unit in minutes (for example, one minute). This should be logged against the accession no. as soon as an examination is sent for vetting.

- h. Vetting activity BI unit in minutes (for example, one minute). This should be logged against the accession no. as soon as vetting is completed.
- i. **Acquisition backlog** – any examination in the RIS waiting to be scheduled (that is, status = requested, in-vetting or vetted) should be logged as acquisition backlog with BI unit for acquisition. When the status is changed to 'completed' backlog value should change to zero.
- j. **Reporting backlog** – any examination in the RIS waiting to be authorised or finalised (status = completed, dictated and transcribed) should be logged as reporting backlog with BI unit for reporting. When the status is changed to 'authorised' or 'finalised' backlog value should change to zero. Addendum reports should not generate a backlog.

Inclusion or exclusion filters – it should be possible to filter for unit time range.

Output – totals should be calculated when applied for a list query. Totals will give the total demand, activity or backlog in time units.

5. Examination code-linked income and cost data items

Each examination performed should have an average income and cost applied to it. Income will be based on NHS tariffs. Local departments should come up with an average cost for studies performed/reported locally. However, different costs will be applied if studies are performed/reported by outsourcing companies.

- a. Income from image acquisition – using national tariff (unless a scan is done for a private referral).
- b. Income from reporting – using national tariff when available.
- c. Acquisition cost – locally defined cost as default, but changed to outsourcing cost if radiographer is from an outsourced provider.
- d. Reporting cost – outsourced reporting cost applied if reporter is from outsourced teleradiology provider, and insourced reporting cost only applied if reporting session type is insourced reporting or if local costs are available.

Filter – it should be possible to filter for a cost range.

Total income and total cost – these should be calculated when applied to a list query. This will allow analysis of the gap between income and cost of service.

6. Examination code-related data items

- a. Modality type
- b. Examination name (with national codes)
- c. Examination type – diagnostic, interventional or treatment (nationally defined)
- d. No. of body parts – for example, CT chest and abdomen would be two body parts (nationally defined)

Filter – it must be possible to filter for single or multiple data items.

7. Machine and examination room locations

- a. Machine unique name/AET
- b. Examination room – unique name and ID
- c. Examination room hospital site
- d. Examination room organisation code

Filter – it must be possible to filter for single or multiple data items.

8. Referring location

- e. Referring location name
- a. Referring location type (emergency department, inpatient, outpatient, GP, other)
- b. Referring location (hospital)
- c. Referring location institution (NHS institution code for hospital/GP surgery)

Filter – it must be possible to filter for single or multiple data items for data items.

9. Referrer

- a. Referrer name
- b. Referrer ID (GMC, NMC, HCPC no.)
- c. Referrer job role
- d. Referring specialty
- e. Referring institution

Filter – it must be possible to filter for single or multiple data items.

10. Operators – maybe multiple

- a. Operator name
- b. Operator ID
- c. Operator job role
- d. Operator specialty
- e. Operator employing institution (NHS trust, outsourced company, and so on)

Filter – it must be possible to filter for single or multiple data items.

11. Primary reporters (there will be one primary reporter)

- a. Reporter name
- b. Reporter ID
- c. Reporter job role
- d. Reporter specialty
- e. Reporter employing institution (NHS trust, private teleradiology company, etc)

Filter – it must be possible to filter for single or multiple data items.

12. Addendum reporters (there will be one primary reporter, but there may be no or multiple addendum reporters)

- a. Reporter name
- b. Reporter ID
- c. Reporter job role
- d. Reporter specialty
- e. Reporter employing institution (NHS trust, private teleradiology company and so on)

Filter – it must be possible to filter for single or multiple data items.

13. Supervising reporter/supervisor

- a. Reporter name
- b. Reporter ID
- c. Reporter job role
- d. Reporter specialty
- e. Reporter employing institution (NHS trust, private teleradiology company and so on)

Filter – it must be possible to filter for single or multiple data items.

14. Actual vetter

- a. Vetter name
- a. Vetter ID
- b. Vetter job role
- c. Vetter specialty
- d. Vetter institution

Filter – it must be possible to filter for single or multiple data items.

15. Patient

- a. Patient name
- b. Patient ID – local
- c. Patient ID – NHS/CHI/HC
- d. Patient DOB
- e. Patient sex
- f. Patient age (at time of examination) – derived data
- g. Ethnicity
- h. Overseas visitor status
- i. Current deceased status – yes/no

Filter – it must be possible to filter for single or multiple data items.

16. Unique numbers

- a. Order no/request no – unique number assigned by the ordering system
- b. Group order no – when multiple examinations are ordered together they will have a common group order number
- c. Accession no – unique number assigned by the scheduling system – RIS
- d. Visit no – when multiple examinations are scheduled together they will have a common group scheduling number

17. GP data items (linked to patient ID)

- a. Registered GP code
- b. Registered surgery/practice
- c. Clinical commissioning group (CCG) code

Filter – it must be possible to filter for single or multiple data items.

18. Miscellaneous

- a. Intended reporter
- b. Intended vetter
- c. Reason codes should include:
 - Reason for cancellation, for example, DNA
 - Reason for holding
 - Reason for re-scheduling
- d. Image acquisition session type – emergency staffing, outsourced staffing or regular staffing
- e. Radiation dose total
- f. Radiation dose units
- g. Reporting session type – NHS job-planned session, emergency session (out-of-hours), private reporting session or insourced backlog reporting session (when a reporter starts a reporting session, the RIS should ask the reporter the type of session for tagging the data); this data item is attached to the RIS once the report status is authorised
- h. Patient category – NHS (non-specified), NHS (stroke), NHS (polytrauma), NHS (headache pathway), NHS (vague symptoms pathway), private, medicolegal and so on (sent by Ordercomms via PV1 segment field 18)
- i. Planned/unplanned – planned examinations need imaging to be scheduled in the future after a certain period of time (for example, six-week or six-month surveillance scans or scan to be done post delivery of baby)
- j. IV contrast type (code)
- k. IV contrast volume
- l. Current workflow status
- m. Requesting examination priority (urgent, routine or 2WW)

- n. Wasted capacity BI unit in minutes – examinations that are cancelled or rescheduled due to DNA; the accession should log wasted capacity BI unit attached to the accession no
- o. No of images in PACS – this should be extracted automatically from the PACS database using standards like DICOM C-FIND, against the unique accession number; it should not be a human-editable data item

Filter – it must be possible to filter for single or multiple data items.

19. Report types and number

- p. Primary report number (0 to 1)
- a. Number of addendums (0 to n)
- b. Autoreport (0 to 1)

Filter – it should be possible to filter for a range of numbers.

Total number – should be calculated when applied for a list query.

Appendix B. Capacity data items

Capacity calculation requires a completely different set of data items compared to demand and activity.

There are two types of capacity of interest to radiology departments:

1. Image acquisition capacity
2. Reporting capacity.

The ability to ascertain capacity with ease will allow departments to plan services better by comparing weekly demands and the capacity available.

1. Image acquisition machine (room) capacity calculation

Capacity calculation requires each 'image acquisition session' created with common parameters to be defined with a unique ID number.

It should be possible to repeat these parameters on a daily or weekly basis.

Each of the criteria below should be sortable and filterable.

For direct scheduling by referrers, each image acquisition session with its own unique ID should be linked to the following capacity data items:

- a. Modality – only one choice allowed, for example, US
- b. Examination codes – for example, UPELD (one, multiple or any)
- c. Referring consultant – one, multiple or any
- d. Referring specialty – one, multiple or any
- e. Priority – 2WW, multiple or any
- f. Referring location type – outpatient (not GP, IP or emergency department) multiple or any
- g. Intended operator – one, multiple or any (if a named operator is used then it will allow the session to be closed when absent)
- h. Intended reporter: one, multiple or any (in the absence of a named intended reporter the session would be closed)
- i. Referring location – one, multiple or any (for example, Doncaster outpatient department)
- j. Referral category: NHS or any
- k. Direct scheduling allowed – yes or no
- l. Room name/machine – one choice only
- m. Duration of the session – total duration of the filtered list should provide capacity calculation in hours and minutes
- n. Session start DT (filtering by date range should be possible)
- o. Session end DT (filtering by date range should be possible)
- p. Staffing levels – regular staffing or emergency staffing
- q. Day of the week
- r. Unique ID number
- s. Session status – for example, available or closed

- t. **Elective capacity** – time reserved for elective appointments within the session and so on in a four-hour CT session only three hours are kept for elective scans
- u. **Emergency capacity** – time reserved for emergency appointments, for example, one hour in the four-hour session is reserved for emergency scans

The data should allow total duration calculation based on any filters that may be applied – to calculate appropriate capacity. By filtering for capacity status 'available' it should be possible to analyse available scheduling capacity for a date range.

2. Reporting, vetting and training capacity calculation

Capacity calculation requires each reporting session created to be defined with a unique ID number.

It should be possible to repeat sessions on a daily or weekly basis.

Each of the criteria below should be sortable and filterable.

Each reporting session with its unique ID should be linked to the following capacity data items:

- a. Modality – one, or any
- b. Referring speciality – one, multiple or any
- c. Priority – 2WW, urgent, routine or any
- d. Referral type – one or multiple (emergency department, inpatient, outpatient, GP or other) – for example, duty radiology or on-call session may only have reporting of emergency department and inpatients
- e. Reporter – named reporter (matched with radiologist job plan)
- f. **Available reporting time** in the session – this is the most important data item. For example, in a duty radiology session of four hours, only three hours may be available for actual reporting, as radiologists maybe disturbed for consultation and vetting. Meanwhile a home reporting/waiting list initiative session may have all of the four hours designated for reporting. A training session may have three hours designated for reporting and one hour for training.
- g. Session start DT (filtering by date range should be possible)
- h. Session end DT (filtering by date range should be possible)
- i. Session type – elective reporting session, emergency reporting session, private reporting session or waiting list ad-hoc session
- j. Day of the week
- k. Unique ID number
- l. Session status – available or closed (based on whether a consultant is on holiday or not)
- m. **Available vetting time** in the session – for example, in a four-hour session – 30 minutes may be identified for vetting
- n. **Available training/supervision time** in the session – for example, in a four-hour session – one hour may be identified for training

By use of appropriate filters it should be possible to analyse available reporting capacity for a date range.

Appendix C. Simple and meaningful dashboards for radiologists

Dashboards with filters can be created using any of the large list of data items listed in Appendix A and Appendix C. However the below dashboards (turnaround times, demand and activity for acquisition and primary report) are most meaningful for ALL radiologists.

This would allow radiologists to have a simple and easily understandable view of:

- a. Bottlenecks, using turnaround time data
- b. Capacity issues, comparing the demand and activity data.

RIS vendors must be able transmit the below data items to the large number of dashboard creating applications (for example, QlikView, Tableau, Microsoft PowerBI and so on)

The RIS data items required for creating the four essential dashboards for radiologists are:

- Request date and time
- Acquisition completion time (by operator) date and time
- Primary report data and time
- Modality
- Referral type (emergency department, inpatient, outpatient, GP or other)
- Specialty of the referrer (as per NHS data dictionary)
- Examination code/description
- Clinical priority (urgent, 2WW and routine)
- Operator (for acquisition activity)
- Reporter (for reporting activity)
- BI unit for acquisition (default average scheduling duration in RIS)
- BI unit for primary reporting (locally agreed average time)
- Autoreport – (yes/no)
- Planned exam – (yes/no)

Turnaround time dashboards

Image acquisition turnaround time (planned exams must be excluded)

- X-axis shows date range (request DT)
- Y-axis shows average turnaround time duration in minutes (request DT to exam completed DT on RIS)

Reporting turnaround time (Autoreports must be excluded)

- X-axis shows date range (completed DT on RIS)
- Y-axis shows average turnaround time duration in minutes (exam completed DT to primary report authorised DT)

Filters available must include:

- Modality
- Referral type (emergency department, inpatient, outpatient, GP or other)
- Specialty of the referrer
- Examination code/description
- Clinical priority (urgent, 2WW and routine)

Demand and activity dashboards

Image acquisition demand

- X-axis – date range will be request date
- Y-axis – sum total of image acquisition BI for each examination in the filtered list for the date range

Image acquisition activity

- X-Axis – date range will be acquisition completed DT
- Y-axis – sum total of image acquisition BI for each examination in the filtered list for the date range

Reporting demand

- X-axis – date range will be acquisition completed DT
- Y-axis – sum of reporting BI for each examination in the filtered list for the date range

Reporting activity

- X-axis – date range will be primary report authorised DT
- Y-axis – sum of reporting BI for each examination in the filtered list for the date range

Filters must include:

- Modality,
- Referral type (emergency department, inpatient, outpatient, GP or other)
- Specialty of referrer
- Examination code/description
- Priority (urgent, 2WW and routine)
- Operator (for acquisition activity)
- Reporter (for reporting activity)





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