# Efficiency Metrics for Imaging Device Productivity

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## Imaging Device Productivity

- To promote use of the DMAIC QUALITY PROCESS (Define, Measure, Analyze, Improve and Control), we suggest formal definitions of five cardinal metrics of efficiency of imaging device productivity: Table Utilization (%), Exam Duration Time (min), Inter-Patient Time (min), Inter-Series Time (min) and Appointment Time Interval (min).
- These metrics are created using time stamps found on the image header of DICOM compliant PACs systems with each examination. We use these metrics to quantify the actual productivity of imaging devices in a manner that is: Standardized across all imaging facilities, Accurate, Remotely and Continuously Available, and Inexpensive to incorporate in actual and on-going use.

## Proposed Definitions

$$\text{Table Utilization (\%)} = \frac{\Sigma \text{ Exam Duration Time over a work period}}{\Sigma \text{ Scheduled Working Time over a work period}}$$
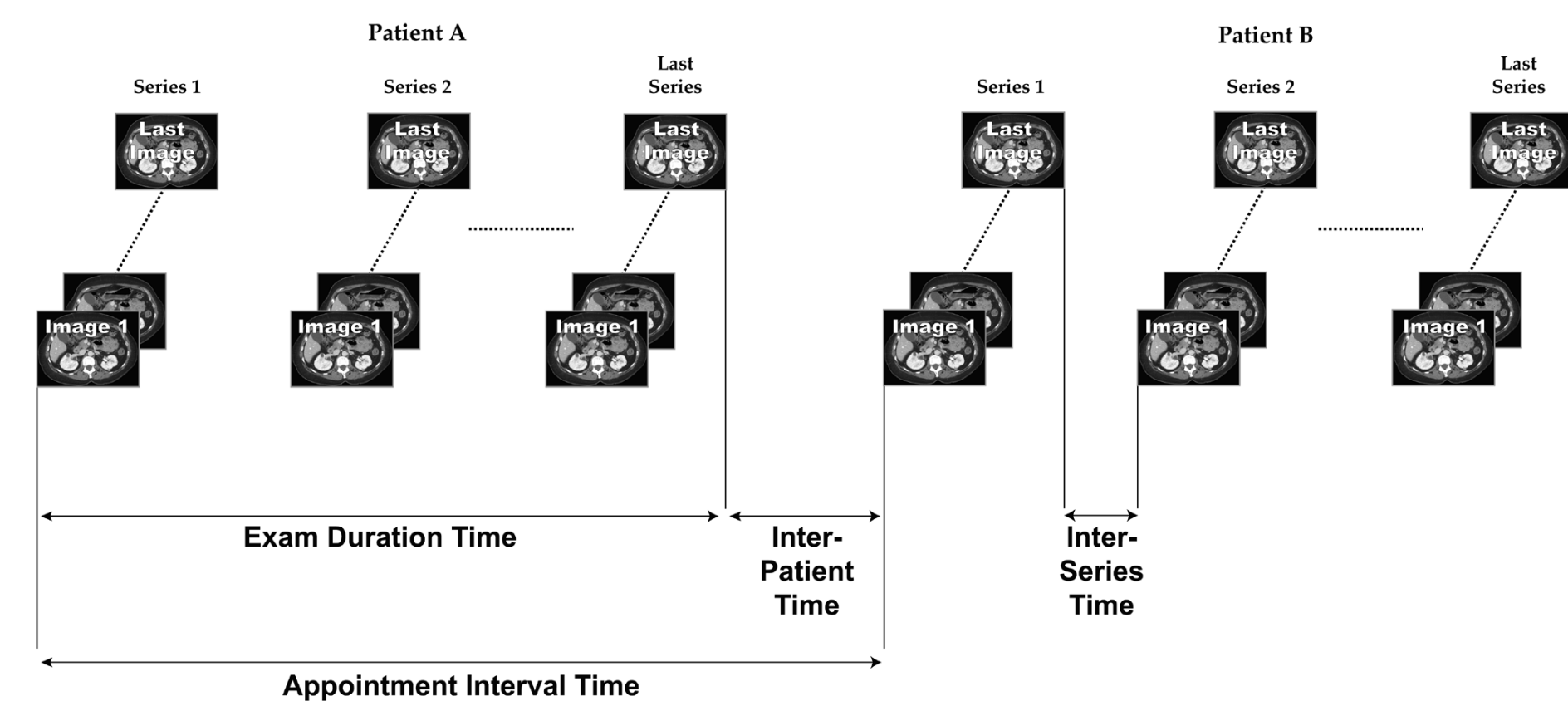


- **Exam Duration** is the time from the first image to the last image acquired (not derived) for a patient.
- **Table Utilization** is computed using this time and normal working hours.
- **Inter-Patient** and **Inter-Series** are also computed from image time stamps.
- **Appointment Interval Time** is useful for accurate scheduling of patient 'slots' for a device.

## DICOM Index Tracker©

A relational database receives a copy of all exams- the Parser deletes all image data, saving textual information. DICOM tags provide wealth of device use based on patient activity. When coupled with exam and protocol acquisition and time stamps, the FIVE METRICS can be calculated. A Web Tool is used to generate the desired reports. Like imaging, any report can be pre-fetched from the database and emailed for administrative use.

| Name | DICOM Tag | Description |
|---|---|---|
| Modality | (0008,0060) | Equipment type |
| Station Name | (0008,1010) | Equipment identifier |
| Patient ID | (0010,0020) | Patient hospital identification number |
| Study Instance UID | (0020,000D) | Study identifier |
| Study Date | (0008,0020) | Date the Study started |
| Study Description | (0008,1030) | Exam description (from RIS) |
| Protocol Name | (0018,1030) | Protocol description (from scanner) |
| Series Instance UID | (0020,000E) | Series identifier |
| Series Description | (0008,103E) | Series description |
| SOP Instance UID | (0008,0018) | Image identifier |
| Acquisition Time | (0008,0032) | Image start time |
| Image Type | (0008,0008) | Original or Derived |
| Acquisition Duration | (0019,105A) | Length of a Series with one vendor's MR |
| X-ray On Time | (0043,104E) | Length of a Series with one vendor's CT |
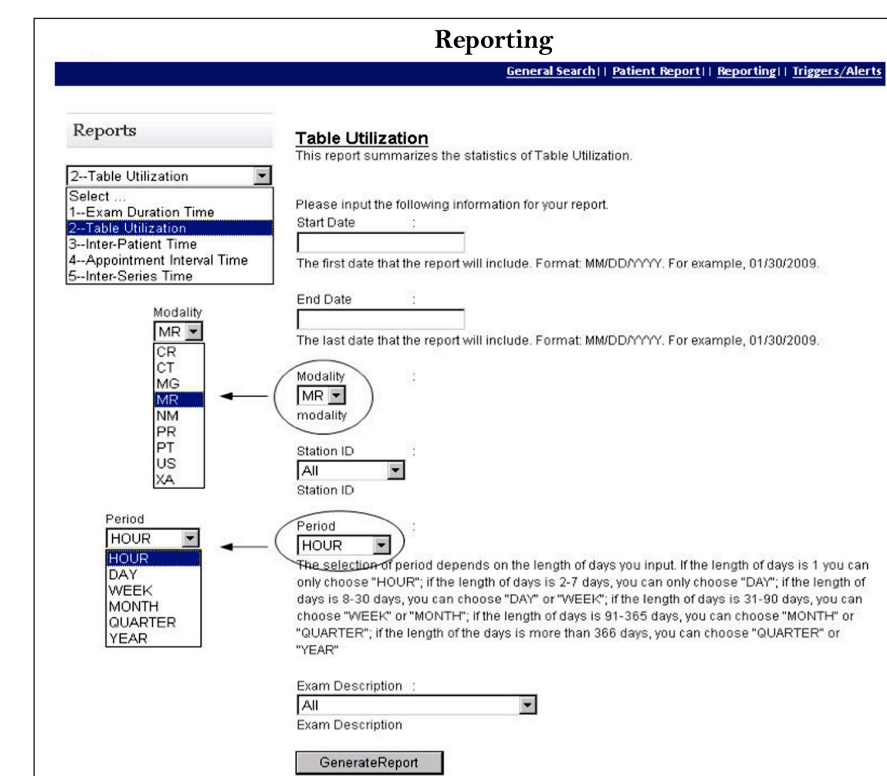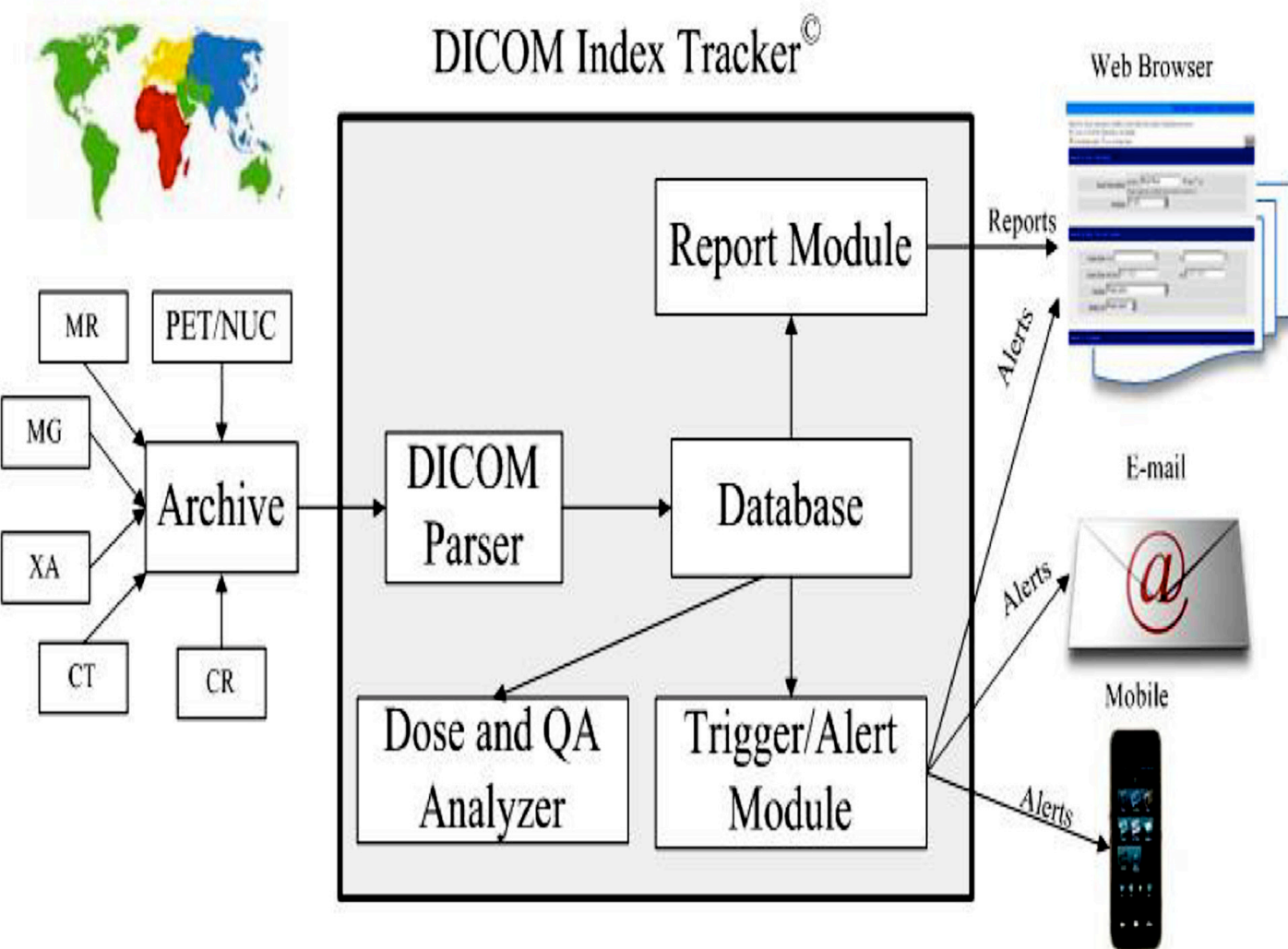


## Sample Reports (Measures)

### MR Exam Duration Report (January 4-8, 2010)
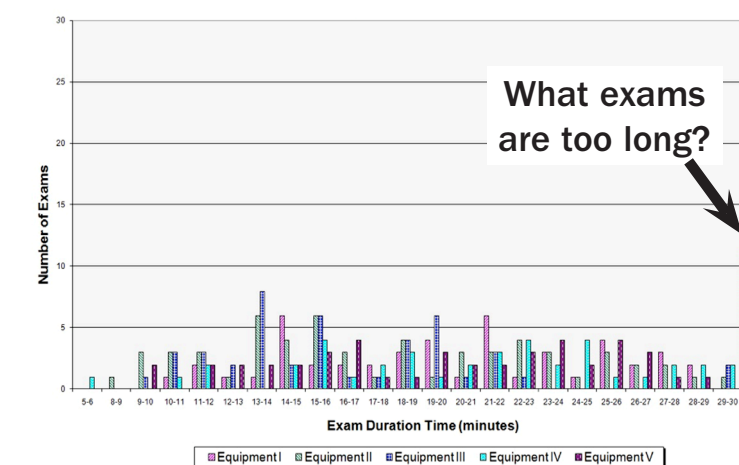

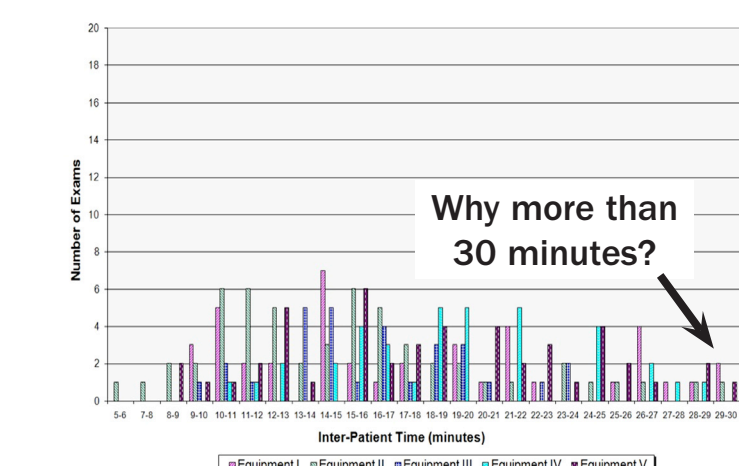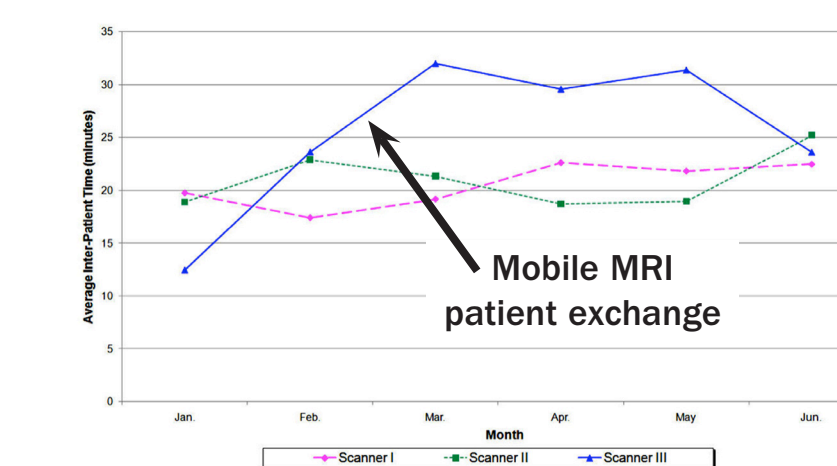### MR Table Utilization (January 4-8, 2010)
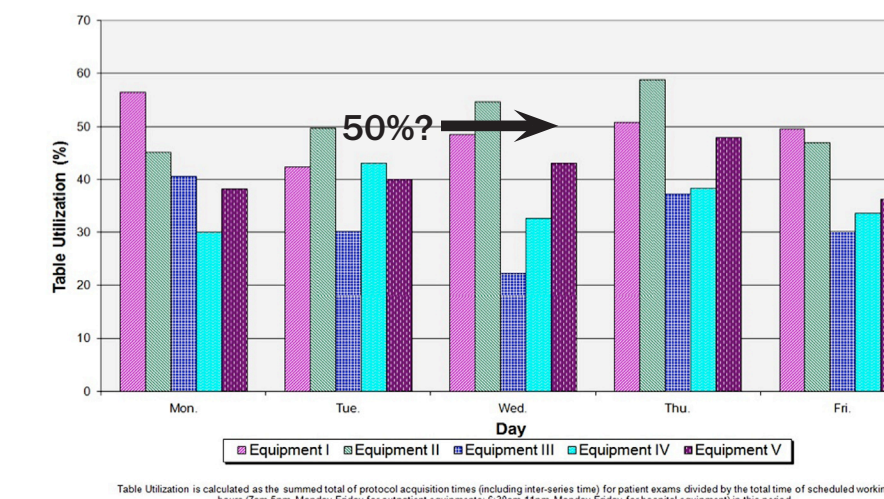

### MR Inter-Series Time Report (January 4-8, 2010)
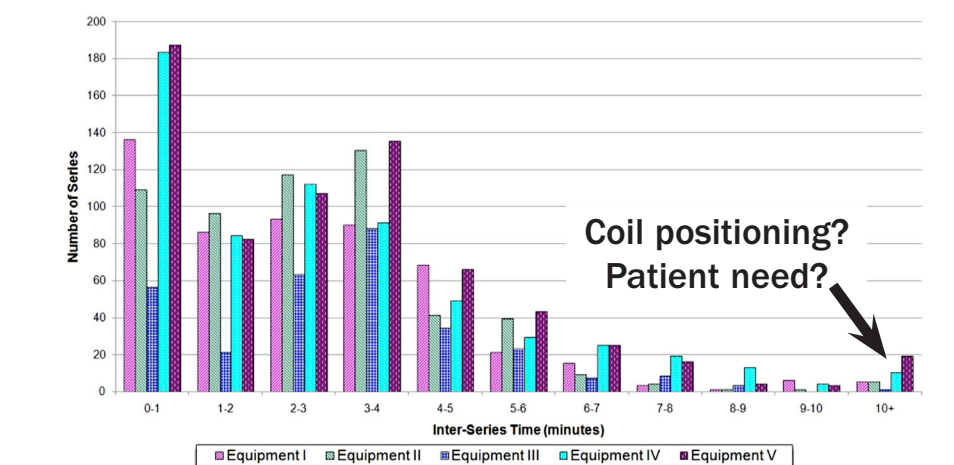

### MR Inter-Patient Time Report (January 4-8, 2010)
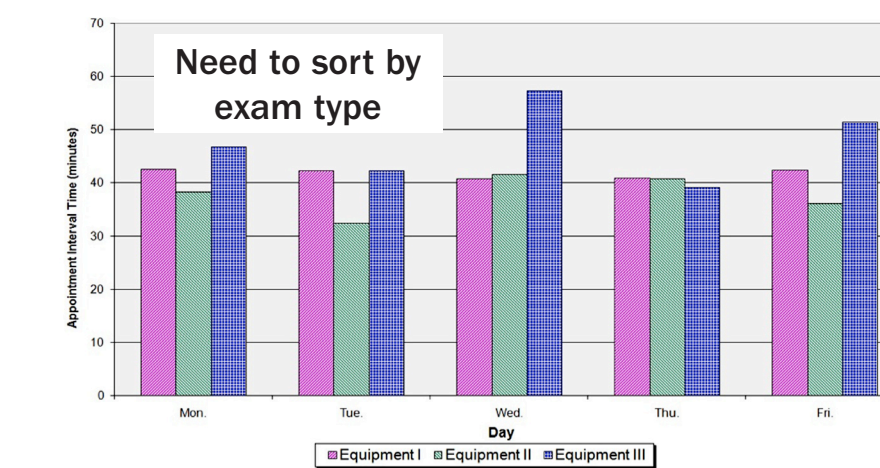

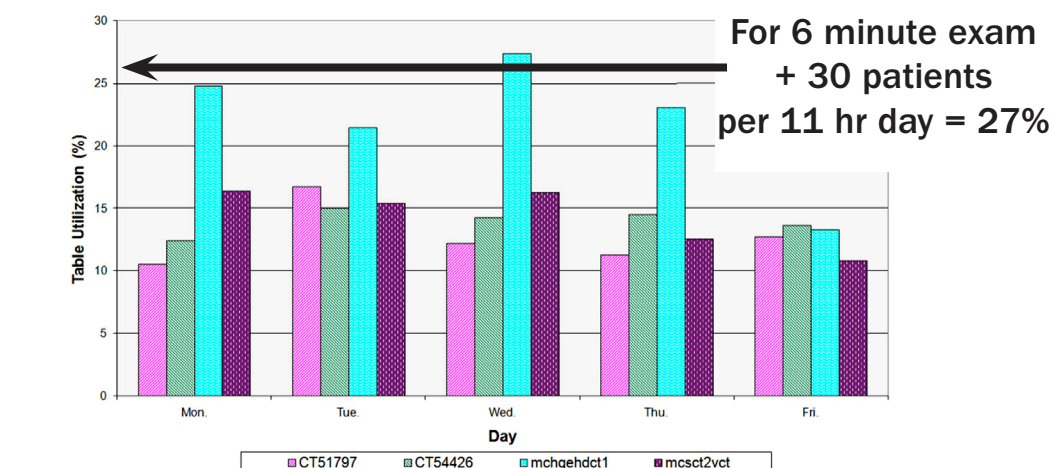### MR Average Monthly Inter-Patient Time Report (January-June 2010)


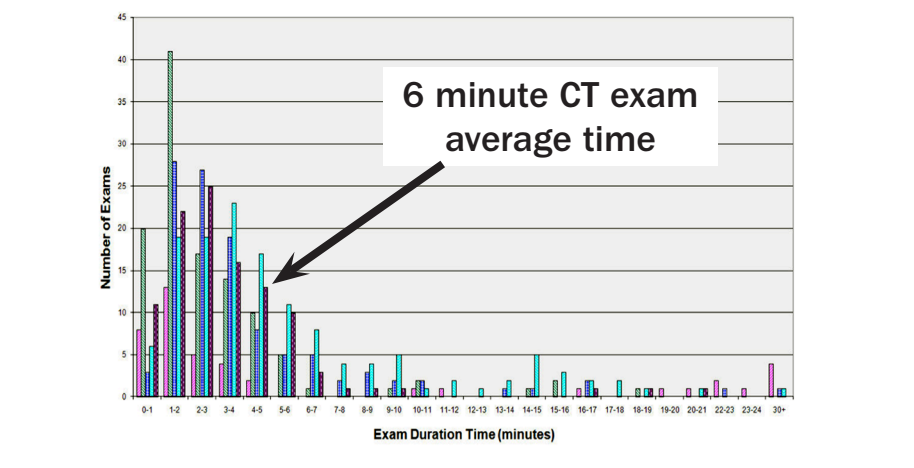### MR Hourly Appointment Interval Time Report (January 7, 21010)


### MR Appointment Interval Time Report (January 4-8, 2010)


### CT Table Utilization Report (July 19-23, 2010)


### CT Exam Duration Report (July 19-23, 2010)


## Efficiency Data Analysis

CMS and State reviews of expensive imaging equipment use a variety of methods to quantitate efficiency. In particular, equipment costing more than $1M (MRI, PET and CT) is selectively targeted for reimbursement review. Historically, a costly and non-standardized method of assessing device utilization was used. DICOM is a robust and fully implemented standard that permits accurate and comparative analysis of efficiency.

- **Table Utilization** is an excellent metric for device use – we benchmark MRI and CT scanners using baseline values (ie, 50% may be a suitable goal for MRI).
- **Exam Duration** times vary considerably, due to prescriptive protocols. What exams are truly (appropriately) lengthy?
- **Inter-Series Delays** can be a source of inefficiency and a benchmark value appears reasonable.
- **Inter-Patient** exchange times are seen to be more than 30 minutes in these data and can optionally be reported out daily.
- **Appointment Interval Time** will vary by the type of exam and should track with the 'slotted' time given by the exam schedule.

## Summary

Five Device Efficiency metrics are defined and proposed for use. DICOM tags (time stamps, patient exam type, device, etc.) as automatically recorded in a database allow web access to create customized and automatically generated Efficiency Reports. In the context of the DMAIC process, QA efforts can be remotely, continuously and inexpensively followed over time. Changes made in staffing and procedures can be assessed using the SAME benchmarked values. Since DICOM is mandated for use with all imaging; institutional comparative benchmarks are immediate and rendered to be valid.