REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
1-10-2011	Final Report	SEP 08 - SEP 11

4. TITLE AND SUBTITLE

Using Lean Six Sigma to Decrease MRI Costs for the Department of Defense in the Reynolds Army Community Hospital Catchment Area, Fort Sill, OK

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Nelson, Christian, MAJ, MS

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Reynolds Army Community Hospital
4301 Mow-Way Street, Fort Sill, Oklahoma, OK 73503

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

USArmy Medical Department Center and School
Bldg 2841 MCCS-HFB (Army-Baylor Program in Health and Business Administrations)
3151 Scott Rd, Suite 1411; Fort Sam Houston, TX 78234-6135

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Lean Six Sigma (LSS) project to increase the productivity of a leased mobile MRI trailer in order to decrease government costs for MRIs in the Reynolds Army Community Hospital (RACH), Fort Sill, Oklahoma catchment area. Improvements were implemented to increase access to direct care MRIs by decreasing appointment times and no-shows, expanding hours and the types of MRIs offered, and changing the business processes. Additionally, a Business Case Analysis (BCA) supported the acquisition, installation, staffing and operation of a fixed MRI. Both aspects of the project were extremely successful. Between May 2009 and April 2011, the LSS project increased MRI production from 167 MRIs per month to 325, resulting in a net savings of ~$1 Million. The BCA was approved and the installation of the fixed MRI was completed in April 2011. From April – September 2011, RACH completed ~500 MRIs per month, three times the baseline. The annual savings for the government is ~$1 Million per year and $7-10 million over the life of the MRI machine.

15. SUBJECT TERMS

Magnetic Resonance Imaging or MRI, MRI Optimization, Lean Six Sigma or (LSS), Business Case Analysis or (BCA), Process Improvement, MRI Productivity, Government Savings, Network Recapture, MRI Operations, No-Shows, Unbooked Appointments

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Education Technician, Ms. Rene Pryor
U	U	U	UU	65	19b. TELEPHONE NUMBER *(Include area code)* 210-221-6443

Army-Baylor University Graduate Program in Health and Business Administration

Using Lean Six Sigma to Decrease MRI Costs for the Department of Defense in the Reynolds Army Community Hospital Catchment Area, Fort Sill, OK

By

MAJ Christian Nelson, MSC, USA

Presented to: MAJ Bradley Beauvais, Ph.D., MBA, MA

October 2011

In partial fulfillment of requirements for the degree:

Masters in Healthcare Administration (MHA)

Abstract

The author initiated a Lean Six Sigma (LSS) project to increase the productivity of a leased mobile MRI trailer in order to decrease government costs for MRIs in the Reynolds Army Community Hospital (RACH), Fort Sill, Oklahoma catchment area. Improvements were implemented to increase access to direct care MRIs by decreasing appointment times and no-shows, expanding hours and the types of MRIs offered, and changing the business processes. Additionally, a Business Case Analysis (BCA) supported the acquisition, installation, staffing and operation of a fixed MRI.

Both aspects of the project were extremely successful. Between May 2009 and April 2011, the LSS project increased MRI production from 167 MRIs per month to 325, resulting in a net savings of ~$1 Million. The BCA was approved and the installation of the fixed MRI was completed in April 2011. The new MRI specifications and layout of the check-in desk, waiting area, changing rooms, and MRI technologist work area were all designed to optimize the productivity of the new system by minimizing steps for staff and patients and providing sight lines to minimize staffing requirements. From April – September 2011, RACH completed ~500 MRIs per month, three times the baseline. The annual savings for the government is ~$1 Million per year and $7-10 million over the life of the MRI machine.

Acknowledgements

I would like to acknowledge the contributions of each of the team members: MAJ (Dr.) Darryl Stinson, Chief, Radiology Department, Ms. Sandra Cooper, Administrative Officer Radiology Department, Ms. Nancy Washburn, MRI Technician Contractor, Ms. Rosa Wages, Analyst Resource Management Division, Mr. Tim Punneo, Chief, Facilities Management Branch, LTC Mark Cotten, Chief, Resource Management Division and 1LT Chet Sosebee, Medical Service Officer.

Additionally, I would like to thank my reader, MAJ Bradley Beauvais, Army-Baylor Professor; my preceptor, LTC Jose Bonilla, Deputy Commander for Administration and my officemate and fellow Baylor resident, MAJ Megan Moakler. I saved the best for last, my wife, Kate and son Alex.

Disclaimer

The views expressed in this study are those of the author and do not reflect the official policy or position of Reynolds Army Community Hospital, the Department of the Army, Department of Defense, or the United States Government.

Statement of Ethical Conduct in Research

Patient confidentiality was strictly adhered to during this research study. All patients' medical information was protected at all times and under no circumstances will be discussed or released to any outside agency.

Table of Contents

List of Tables

List of Figures

List of Appendixes

1.0. Introduction.

In FY 2008, TRICARE beneficiaries under 65 years of age had approximately 5,193 outpatient, non-emergent MRIs in the Reynolds Army Community Hospital (RACH) catchment area. Network MRIs accounted for 3,219 MRIs at a cost of approximately $1,400,000 (average cost approximately $435 per MRI). Additionally, 1,938 direct care MRIs were performed through a contracted 45 hours a week mobile MRI trailer located on-site next to the hospital. On 28 November 2005, Great Plains Regional Contracting Office awarded an MRI contract to Dockside Imaging and services officially began on 23 January 2006.

The MRI is housed in a semi-trailer van and parked on a pad adjacent to the Emergency Room and Radiology Department of the hospital. The MRI procedures done at RACH are outpatient, non-contrast procedures. There are no emergency cases and all appointments are prescheduled. The hours of operation are from 0730 to 1630, Monday to Friday. The contractor, Dockside Imaging, charges approximately $487,000 per year ($40,583 per month) with FY2010 as the final option year of the original contract. Total cost to the government in FY 2008 for the 5,193 MRIs was approximately $2,000,000. This does not include the salary of the RACH radiologists' time for the approximately 1,000 MRIs they read.

The team decided to maximize the current process in advance of spending over $2 million on the acquisition and installation of a fixed MRI and accessories. The purpose of this Green Belt Lean Six Sigma (LSS) project is to recapture network MRIs in the RACH catchment area and improve MRI efficiency at RACH. Included in the appendix is a BCA for the purchase of a fixed MRI to provide MRI services inside the facility at RACH. The MRI BCA includes the purchase price of the machine, construction/installation, warranty/maintenance, supplies, and staffing with technicians and radiologists. The LSS Define, Measure, Analyze, Improve and

Control (DMAIC) will be utilized for the methodology for this project.

RACH's strategic plan for FY 2008-2010 has six strategic constructs: 1) Institute a provider-centric culture, 2) improve patient safety and documentation, 3) focus on Soldier medicine, 4) improve customer experience internal and external, 5) optimize productivity to maintain a full service community hospital and 6) continue new mission/expansion (RACHOO, 2009). The MRI LSS project addresses each of the strategic constructs, but most notably, this project follows the guidance of optimizing productivity to maintain a full service community hospital and continue new mission/expansion.

2.0. Define.

Problem Statement:

In FY 08, $1.4 million per year was spent on Network MRI's for network, non-emergent and out-patient MRI's in the Reynolds Army Community Hospital (RACH) catchment area for beneficiaries younger than 65 year old. Un-booked appointments and a high rate of no-show appointments contribute to Network expense and underutilization of MRI equipment at RACH. Therefore, the cost per completed MRI at RACH has not been minimized. Also, appointments can only be scheduled Mon – Fri during normal business hours, thus creating a lack of MRI appointment time choices for patients.

Goal Statement:

Analyze the available hours of operation to determine if current operating hours are sufficient to handle the demand for MRI's. The goals are: increase the number of completed MRI

appointments per month at RACH by 50%; reduce both the no-show rate and un-booked appointment rate by 20% each; and reduce the cost per completed MRI at RACH by 10%.

Project Scope:

This study includes all beneficiaries eligible to use the MRI at Reynolds Army Community Hospital. The scope of the project starts *after* a provider has made the decision to refer the patient for an MRI. The process starts when the provider enters the referral into Armed Forces Health Longitudinal Technology Application (AHLTA). The process ends after the MRI is completed and the patient is escorted from the MRI trailer to the Radiology Department. The provider writing the referral was purposely left out of the scope of the project because it was felt that utilization management of MRI referrals is worthy of its own LSS project (Generation 3). Similarly, a LSS project on the purchase and utilization of a new MRI should be completed in the future (Generation 2).

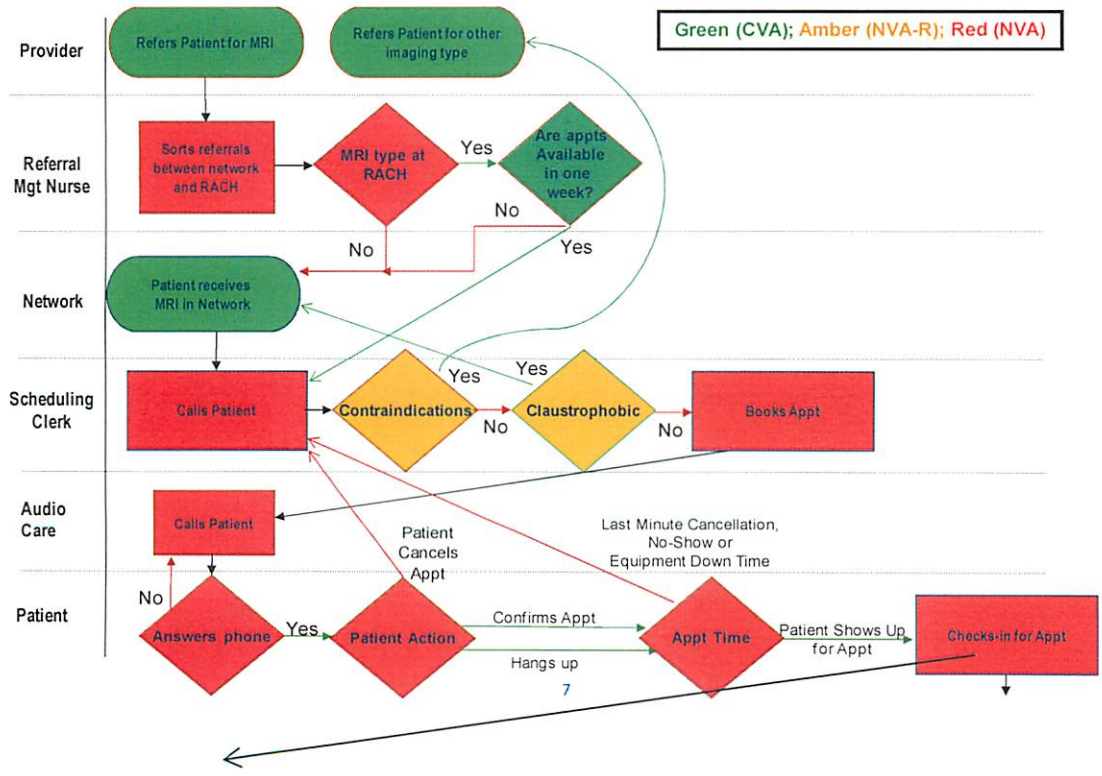
Multi-Generation Project Plan (MGPP)

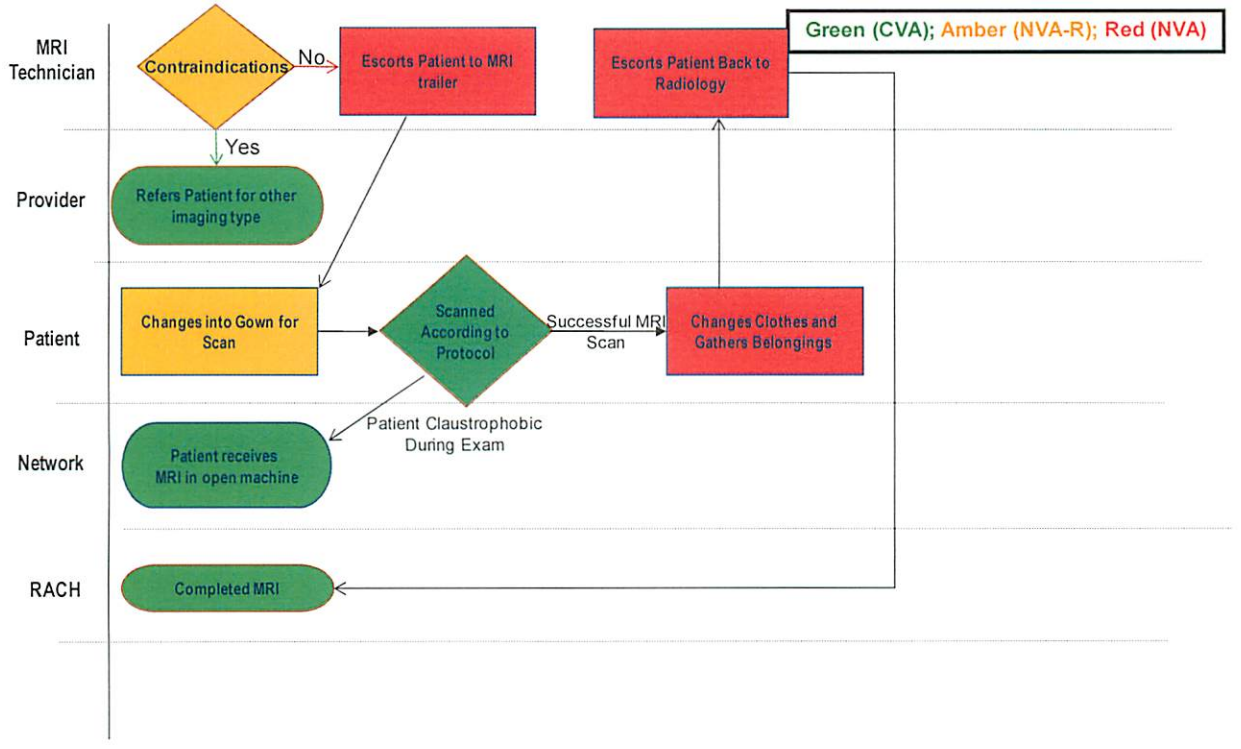
	Generation 1 Jan 2009 – Sep 2010	Generation 2 Mar – Oct 2011	Generation 3 Oct 2011– Sep 2012
Vision	High utilization rate of expensive capital equipment and more MRI appts to increase MRIs completed at RACH.	Decrease cost of RACH MRI by purchasing a new large bore MRI located inside Rad capable of fast PCT.	Providers only refer patients for Medically Necessary MRIs.
Process Generation	Increased utilization of capacity, efficient PCT, expand hours of operation.	Current MRI lease is not cost efficient compared to owning an MRI located inside the Rad Dept.	Current provider referral practices have led to significantly increased MRI utilization rates per 1000 beneficiaries.
Platforms / Technology	Hours of operations analysis, patient flow analysis, scheduling process analysis.	Faster PCT and a large bore MRI support more in-house imaging and less to the Network.	Provider Referral Pattern Analysis. Managed Care, Clinical Practice Guidelines for the utilization of MRI.

Figure 1. Multi-Generation Project Plan (MGPP)

Process Map:

The main steps that lead to a completed MRI exam at RACH are: 1) Provider refers patient for an MRI. 2) The referral management nurse determines that RACH can perform the MRI. 3) RACH has MRI appointments available within one week. 4) The MRI scheduling clerk calls the patient and confirms that there are no contraindications. 5) The clerk confirms that the patient is not claustrophobic. 6) The appointment is booked by the MRI scheduling clerk. 7) Audio Care calls the patient with an automated appointment reminder. 8) The patient confirms the appointment time. 9) The patient shows-up and checks-in for the appointment. 10) The MRI technician reconfirms that there are no contraindications. 11) The MRI technician escorts patient to the MRI trailer. 12) The patient changes into a gown for the scan. 13) The patient is scanned according to the protocol. 14) The patient changes back into their clothes and gathers their belongings. 15) The MRI technician escorts the patient back to the Radiology Department. 16) The process results in a completed MRI exam at RACH.





8

Figure 2: MRI Process Map

Business Impact:

The estimated financial savings from this project are $185K in FY09 and $371K per year in FY10-15 resulting in a total of $2.4 million in savings over the course of project. On average RACH completes 2,004 MRIs per year (167 per month x 12 months). The primary project goal is a 50% increase in completed MRIs at RACH, which would have resulted in 3,006 completed exams per year. In FY08 the Department of Defense paid an average of $450 for each network MRI completed in the Fort Sill catchment area. RACH pays a contractor $80 to read each MRI. Therefore, each additional MRI completed at RACH would result in a net savings of$370 for the DoD. The projected annual savings to the DoD is $371k per year ($370 per MRI * 1002 additional MRIs per year) for FY10-FY 15. The FY 09 projected savings reflect six months of

increased production. The projected savings assume no additional costs to RACH other than the cost to read the MRIs.

Project Team:

After enrollment in the U.S. Army's LSS Green Belt course, this project was initiated as the Green Belt certification project. The initial project team consisted of, CPT Christian Nelson, Army-Baylor MHA Resident, MAJ (Dr.) Darryl Stinson, Chief, Radiology Department, Ms. Sandra Cooper, Administrative Officer Radiology Department, Ms. Nancy Washburn, MRI Technician Contractor, Ms. Rosa Wages, Analyst Resource Management Division, Mr. Tim Punneo, Chief, Facilities Management Branch, LTC Mark Cotten, Chief, Resource Management Division and 1LT Chet Sosebee, Medical Service Officer.

Suppliers, Inputs, Process, Outputs, and Customers (SIPOC) analysis:

Suppliers	Inputs	Major Process Steps	Outputs	Customers
Contractor	Referral for MRI	1. Provider Refers Pt for MRI	Completed MRIs / Month	Patient
Patient	Hours of MRI Availability	2. Pt scheduled for MRI Appt	Cost per Completed MRI	DoD
MRI Techs	Avg MRI Appt Length (Minutes)	3. Audio Care Appt Reminder	No-Show Rate	
Radiologists	Cost of MRI Contract / Month	4. Pt Check In	Un-booked Appointment Rate	
Referring Providers	# of Available Appointments	5. Patient Prep	DPMO	
Radiology Clerk	# of Booked Appointments	6. MRI Prep		
Scheduling Clerk		7. Pt Scan According to Protocol		
DoD		8. Patient Released		

Input Metrics	Process Metrics	Output Metrics	
Hours of MRI Availability	# of MRI Appointments Available / Month	Completed MRIs / Month	**Speed**
Avg MRI Appt Length (Minutes)	# of MRI Appointments Available / Month	Completed MRIs / Month	**Speed**
Cost of MRI Contract / Month	Completed MRIs / Month	Cost per Completed MRI	**Cost**
# of Booked Appointments	# of Kept Appointments	DPMO	**Quality**
# of Available Appointments	# of Un-Booked Appointments	DPMO	**Quality**

Figure 3. Suppliers, Inputs, Process, Outputs, Customer (SIPOC)

Voice of the Customer/Business:

Currently, appointments for MRI's are only available during normal business hours (0730 to 1630). The Voice of the Customer, patients requiring MRIs, request that appointments be made available after normal work hours and on Saturdays to meet their needs. The Voice of the Business wants to increase the number of MRIs completed at RACH, decrease variability, decrease the process cycle time, decrease defects (wasted available MRI appointments), and achieve a reduction in the cost of MRI's.

3.0 Measure

The primary data sources for the project were the Military Health System Management Analysis and Reporting Tool (M2) and the contractor MRI Productivity report. M2 is an ad hoc query tool that the Military Health System (MHS) uses to capture both direct care encounters and purchased care claims as data sources. M2 is for detailed trend analysis, summary and detailed views of population, clinical, and financial data from all MHS regions worldwide (MHSHD, 2008). The M2 data was used to calculate the number, cost and type of network MRIs available for recapture. The scope of the network MRIs was limited to TRICARE beneficiaries less than 65 years of age, because Medicare, not the Department of Defense, is the primary payer for network care for beneficiaries 65 and older. Additionally, the Department of Defense cannot be reimbursed by Medicare for care provided in an MTF (AFPS, 2009). Emergent and in-patient MRIs were excluded because those could not be recaptured from the network.

In FY 2008, TRICARE beneficiaries under 65 years of age had approximately 5,139 outpatient, non-emergent MRIs in the Reynolds Army Community Hospital (RACH) catchment area. Network MRIs accounted for 3,219 MRIs at a cost of approximately $1,400,000 (average cost approximately $435 per MRI). Additionally, 1,920 direct care MRIs were performed through a contracted 45 hours a week mobile MRI trailer located on-site next to the hospital. The contractor, Dockside Imaging, charges $487,000 per year ($40,583 per month) with FY2010 as the final option year of the original contract. Total cost to the government in FY 2008 for the 5,139 MRIs was approximately $2,000,000. This does not include the salary of the RACH radiologists' time for the approximately 1,000 MRIs they read.

The Composite Health Care System (CHCS) data was used to measure direct care MRIs completed and no-shows, but it was determined that there was a data quality issue. It appeared

that no-shows were deleted in CHCS if the patient was rescheduled for another appointment after no-showing. Eventually the contractor MRI Productivity Report (MPR) was used as the main data source for the project.

Operational Definitions:

- **MRI Contract:** RACH has a contract with Docside Imaging for $487K / year to provide the MRI techs and a mobile MRI trailer to complete MRIs at RACH (does not include reading the MRIs).
- **Available Hours:** Number of hours MRI is available for scanning. The contract specifies the hours of the MRI trailer are from 0730 to 1630, Monday through Friday, with the exception of 10 federal holidays and nine training holidays. Therefore, the MRI trailer should be open approximately 242 days per year X 9 hours per day = 2178 hours per year.
- **Template:** Created by the Chief of Radiology. The MRI template calls for 11 appointments a day, every 45 minutes starting at 0730 and finishing at 1545. The last 45 minutes (1545-1630) remain as flex-time for longer appointments (arthrograms), unforeseen circumstances, and clean-up.
- **Available Appt (AA):** An MRI appointment available for booking. Appointments are opened for booking by Medical Management (MM). MM opens a schedule based on the open hours and days specified in the contract and a template created by the Chief of Radiology. The template in use for the trailer calls for 11 appointments a day, every 45 minutes starting at 0730.
- **Booked Appointments (BA):** An available MRI appointment booked with a patient.
- **Kept Appointment (KA):** An appointment in which the scheduled patient shows up.

- **Completed MRI (CM):** An appointment that results in a completed MRI with no defects.
- **Defect (D):** An available MRI appointment that does not result in a completed MRI Exam. Categories of defects include: Un-Booked, No-Show, Equipment Down, Contraindication or Claustrophobic.
    - **Un-Booked (UB):** All available appointments that are not booked.
    - **Last Minute Cancel (LMC):** A booked appointment canceled by the patient but it is not re-booked. If a patient cancels their appointment , but another patient is booked into that appointment, it is counted as a booked appointment. That cancelation would not show up in this data because the same appointment cannot be counted twice.
    - **No-Show (NS):** When the patient does not show-up for their booked appointment. An appointment is also counted a No-Show if the patient shows-up too late to complete the MRI without causing a delay for the next patient. The contractor has the discretion to make that judgment call.
    - **Equipment Down (ED):** An appointment that is canceled or aborted due to equipment failure, loss of electricity or equipment upgrade or service. ED also includes the unavailability of an MRI technician, since it is incumbent on the contractor to provide the MRI equipment and personnel.
    - **Contraindication (CI):** An appointment that is not initiated for medical/safety reasons. The patient shows-up for their appointment, but they do not pass the eligibility screening/questionnaire given by the contractor. Patients have a contraindication if they have a pacemaker, shrapnel in their body, etc.

- **Claustrophobic (CP):** An appointment that is aborted due to the patient's inability to remain still in a confined space for the duration of the exam.
- **D** = UB + NS + ED + CI + CP

- **Available Appointments (AA) = Completed MRIs (CM) + Defects (D)**
- **Opportunity (O):** An available appointment
- **Defects Per Million Opportunities (DPMO):** Total Defects per 1,000,000 available appointments
- **Sigma Quality Level (SQL):** An indicator of how often defects are likely to occur; higher SQLs equate to fewer defects, conversely lower SQLs equate to more defects.
- **Un-Booked Appt Rate** = Un-Booked Appts / Available Appts (for given period of time)
- **No-Show Rate** = No-Show Appts / Booked Appts (for a given period of time)
- **MRI Productivity report:** Prepared by the contractor and includes the following data:
  - Monthly Totals of:
    - available MRI appointments
    - booked appointments
    - completed MRIs
    - un-booked appointments
    - appointments canceled or aborted due to equipment downtime
    - patient no-shows
    - exams not initiated due to a patient contraindication
    - exams aborted due to claustrophobic patients
    - Un-Booked Rate
    - No-Show Rate

- **Process Cycle Time (PCT)** = The amount of time it takes to actually complete an MRI. Time starts when the MRI Tech meets the patient in the Radiology Dept and ends after the MRI Tech escorts the patient back to the Radiology Dept.
    - Note: The contractor declined the request to follow patients through the MRI process and time each of the steps. Therefore, this study only includes data on the planned appt length (min). The PCT is assumed to be the planned appt length, not the actual PCT.
- **Cost per MRI** = (Cost of Contract / # of Completed MRIs) + $80
    - Note: The Cost per MRI is calculated for a specific time period, usually per month or per year. $80 is added to the equation to account for the separate contract cost of reading the MRI. In FY 2008, approximately half of the MRIs at RACH were read by Radiologists on staff and half were read by the contractor. Since this is beyond the scope of Generation 1, we will simply use the approximately $80 contract cost to read each MRI. We must include the cost to read the MRI in our Cost per MRI because the cost to read the MRI is included in the cost of an MRI purchased by TMA in the network.

Monthly Productivity Report:

The MPR is updated monthly by the contractor and posted on RACH's intranet. The MPR includes monthly totals for: available MRI appointments, scheduled appointments, un-booked appointments, appointments canceled or aborted due to equipment downtime, last minute cancelations, patient no-shows, exams not initiated due to a patient contraindication and exams aborted due to claustrophobic patients. Each category (excluding available MRI appointments) is mutually exclusive, and each available appointment can only be assigned to one category. So the

following equations hold true:

Available MRI Appts = Un-booked + Booked Appts

Booked Appts = Equipment Down + Last Minute Cancel +

No-Show + Contraindication + Claustrophobic + Completed MRI Exams

Available MRI Appts = Un-booked + Equipment Down + Last Minute Cancel +

No-Show + Contraindication + Claustrophobic + Completed MRI Exams

Month Year	Available MRI Appts	Booked Appts	Un-Booked (UB)	% UB	Equipment Down (ED)	% ED	Last Minute Cancel (LMC)	% LMC	No-Show (NS)	% NS	Contraindication (CI)	% CI	Claustrophobic (CP)	% CP	Completed MRI Exams	Completion %
Oct-06	225	225	0	0.0%	0	0.0%	10	4.4%	20	8.9%	0	0.0%	5	2.2%	190	84.4%
Nov-06	209	208	1	0.5%	1	0.5%	9	4.3%	25	12.0%	2	1.0%	3	1.4%	168	80.4%
Dec-06	209	203	6	2.9%	1	0.5%	9	4.3%	18	8.6%	0	0.0%	0	0.0%	175	83.7%
Jan-07	231	202	29	12.6%	0	0.0%	4	1.7%	22	9.5%	1	0.4%	1	0.4%	174	75.3%
Feb-07	198	186	12	6.1%	0	0.0%	4	2.0%	25	12.6%	0	0.0%	2	1.0%	155	78.3%
Mar-07	242	236	6	2.5%	7	2.9%	7	2.9%	22	9.1%	0	0.0%	1	0.4%	199	82.2%
Apr-07	231	225	6	2.6%	0	0.0%	1	0.4%	23	10.0%	0	0.0%	1	0.4%	200	86.6%
May-07	231	221	10	4.3%	6	2.6%	3	1.3%	24	10.4%	0	0.0%	2	0.9%	186	80.5%
Jun-07	231	213	18	7.8%	6	2.6%	8	3.5%	35	15.2%	0	0.0%	1	0.4%	163	70.6%
Jul-07	220	200	20	9.1%	2	0.9%	7	3.2%	26	11.8%	0	0.0%	2	0.9%	163	74.1%
Aug-07	253	238	15	5.9%	10	4.0%	5	2.0%	22	8.7%	0	0.0%	2	0.8%	199	78.7%
Sep-07	209	186	23	11.0%	0	0.0%	6	2.9%	30	14.4%	0	0.0%	1	0.5%	149	71.3%
Oct-07	225	212	13	5.8%	15	6.7%	5	2.2%	29	12.9%	0	0.0%	1	0.4%	162	72.0%
Nov-07	209	184	25	12.0%	22	10.5%	6	2.9%	16	7.7%	0	0.0%	0	0.0%	140	67.0%
Dec-07	198	146	52	26.3%	0	0.0%	6	3.0%	10	5.1%	0	0.0%	0	0.0%	130	65.7%
Jan-08	220	150	70	31.8%	0	0.0%	5	2.3%	9	4.1%	1	0.5%	3	1.4%	132	60.0%
Feb-08	209	185	24	11.5%	0	0.0%	6	2.9%	16	7.7%	0	0.0%	1	0.5%	162	77.5%
Mar-08	231	206	25	10.8%	14	6.1%	3	1.3%	26	11.3%	0	0.0%	0	0.0%	163	70.6%
Apr-08	242	200	42	17.4%	8	3.3%	1	0.4%	19	7.9%	2	0.8%	2	0.8%	168	69.4%

May-08	220	192	28	12.7%	0	0.0%	2	0.9%	28	12.7%	2	0.9%	1	0.5%	159	72.3%
Jun-08	231	218	13	5.6%	3	1.3%	8	3.5%	12	5.2%	0	0.0%	1	0.4%	194	84.0%
Jul-08	220	200	20	9.1%	26	11.8%	2	0.9%	23	10.5%	0	0.0%	1	0.5%	148	67.3%
Aug-08	231	205	26	11.3%	0	0.0%	2	0.9%	15	6.5%	0	0.0%	1	0.4%	187	81.0%
Sep-08	220	201	19	8.6%	2	0.9%	4	1.8%	16	7.3%	2	0.9%	2	0.9%	175	79.5%
Oct-08	242	224	18	7.4%	46	19.0%	4	1.7%	15	6.2%	0	0.0%	0	0.0%	159	65.7%
Nov-08	176	153	23	13.1%	8	4.5%	4	2.3%	7	4.0%	1	0.6%	1	0.6%	132	75.0%
Dec-08	231	211	20	8.7%	0	0.0%	2	0.9%	22	9.5%	1	0.4%	0	0.0%	186	80.5%
Jan-09	200	195	5	2.5%	0	0.0%	3	1.5%	14	7.0%	1	0.5%	1	0.5%	176	88.0%
Total	=sum(															

Table 1. Monthly MRI Productivity Report

Timeline of MRIs at RACH and the Sigma Quality Level:

The number of MRIs completed at RACH each month has been trending down over the baseline time period (October 2006 – January 2009).

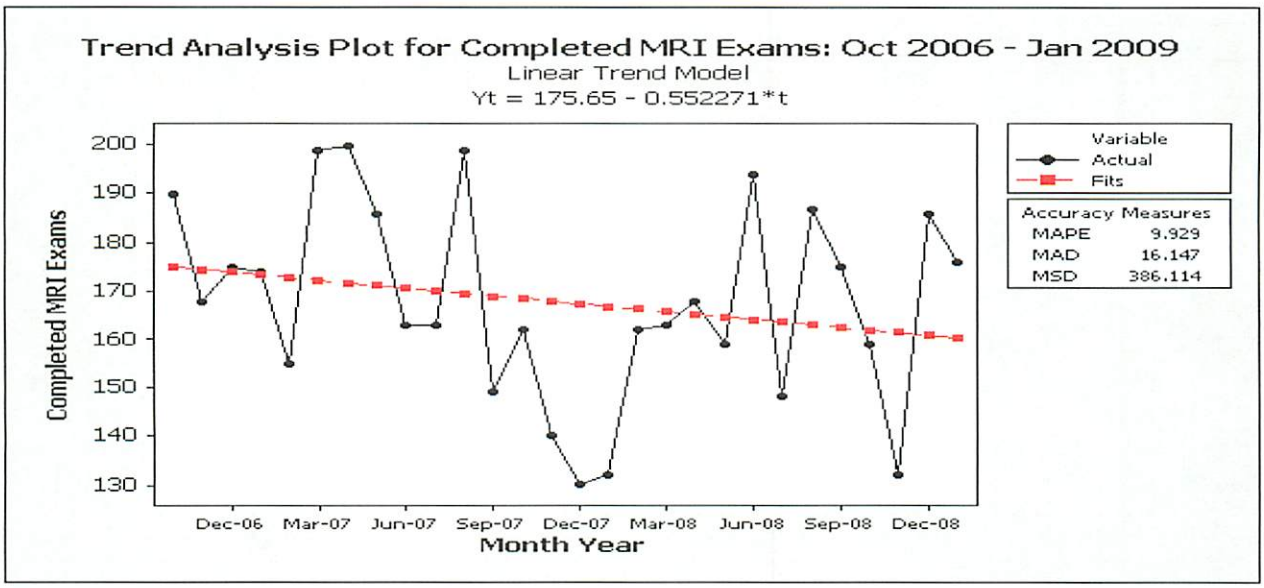


Figure 4. Trend Analysis of MRIs Completed at RACH

The graph (Figure 5) below depicts the "Monthly Available MRI Appointments, Booked, and Completed MRI Exams." The three time lines indicate that the process routinely underperforms. As a result of the poor process performance, MRI's have to be completed in the

Network and at great additional expense to the Army. Only 167 MRI's on average are completed every month, when the expected output is 222 every month.

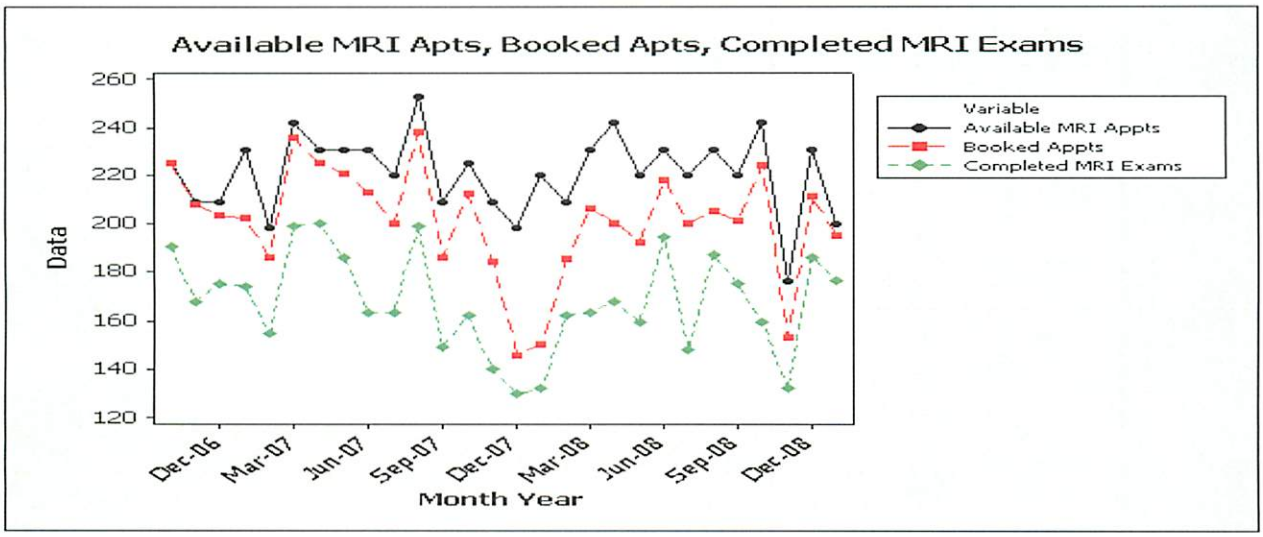


Figure 5: Monthly Available MRI Appointments, Booked, and Completed MRI Exams.

During those 28 months, a total of 6,194 MRI appointments were available for booking at RACH; 4,694 MRI exams were actually completed and 1,500 appointments were wasted. The completion Rate (CR) was 75.8% and the defect rate was 24.2%. This equates to 242,170 Defects Per Million Opportunities (DPMO) and a Sigma Quality Level of 2.20.

Measurement Systems Analysis:

A Measurement System Analysis of the MRI productivity data was conducted to determine its reliability and validity. Comparing CHCS and the MRI productivity report, respectively 4,690 and 4,694 MRIs were completed at RACH from Oct 06- Jan 09. That equates to 0.09% difference, which is acceptable to the group. Additionally, all 28 monthly totals in CHCS and the productivity report were within one MRI completed of each other.

Statistical Control (I-MR Analysis):

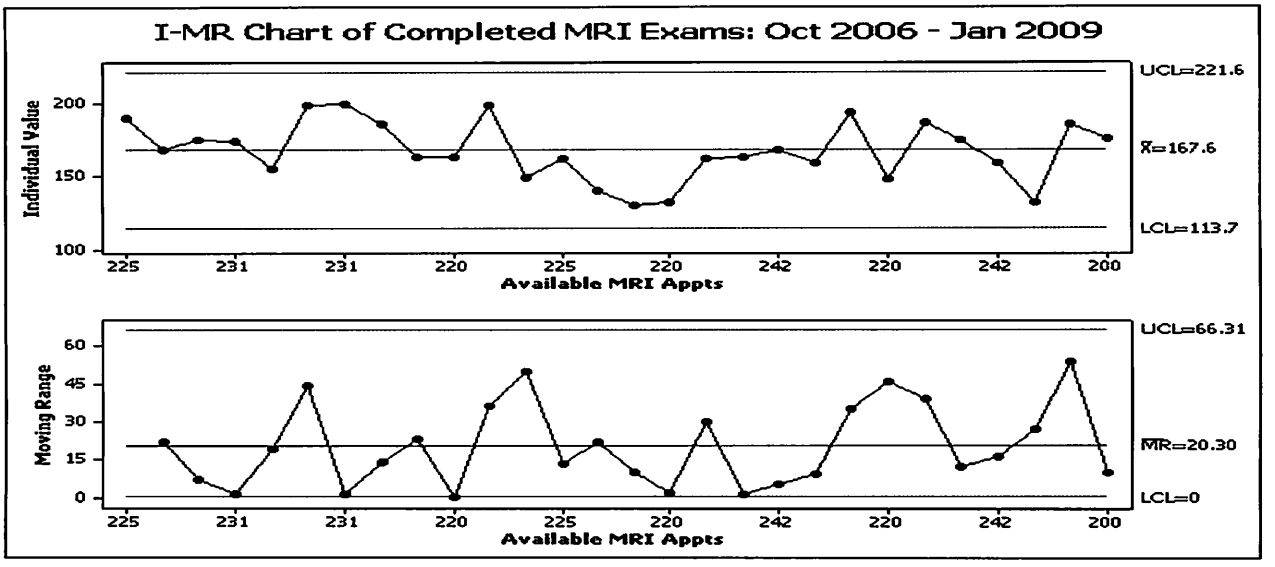


Figure 6. I-MR Chart of MRI Exams Completed at RACH (Oct 06 – Jan 09)

Voice of the process is reflected in the control limits. The I-MR analysis of completed exams indicates the process is stable and in-control, no un-assigned causes of variation, only common cause variation. All data points are within the statistical control limits. Statistical control has to be achieved prior to test for capability.

Process Capability of MRIs Completed at RACH:

A histogram of the data as shown in the Process Capability of Completed MRI Exams (Figure 7) depicts a relatively normal distribution.

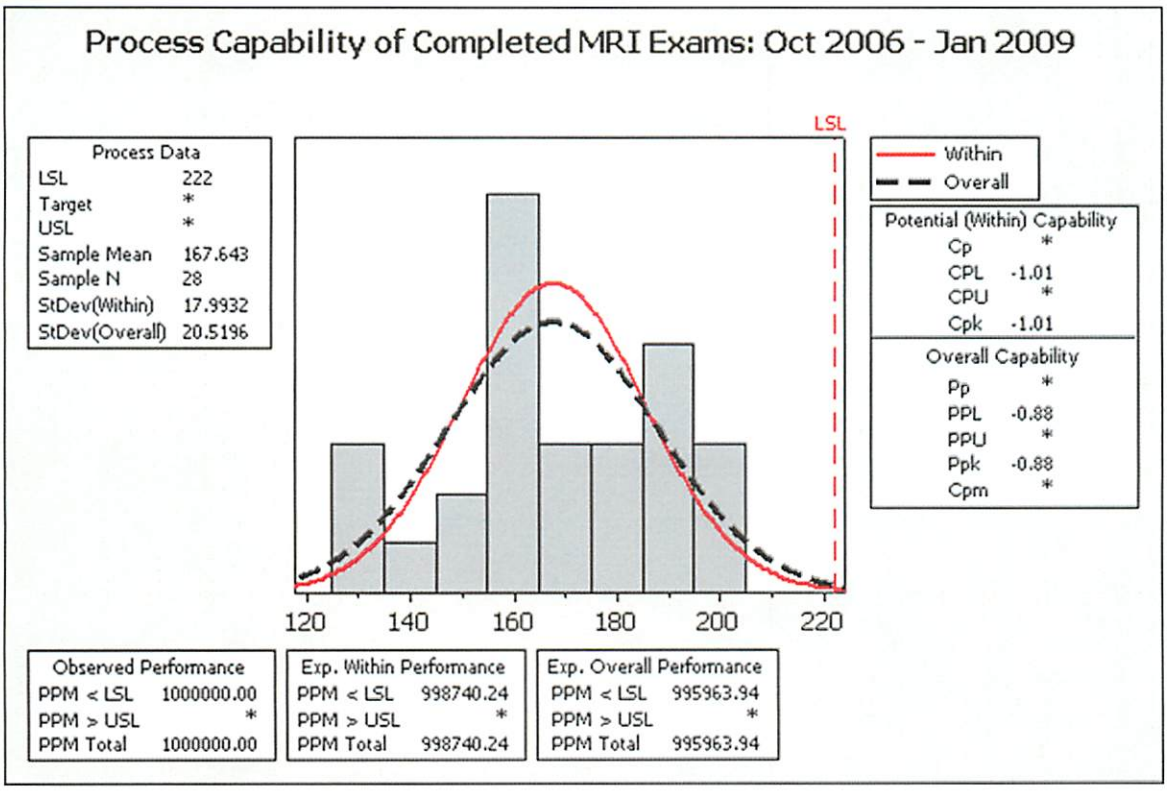


Figure 7. Process Capability of MRIs Completed at RACH. Voice of the process is reflected in the control limits. Voice of the customer is reflected in the specification limits.

The process capability analysis of completed exams indicate a process with a normal bell shape and similar Within and Overall curves. The process has a single LSL representing the demand or volume of MRI's planned for on a monthly basis. The process is consistently under performing and not meeting the demand of 222 MRIs monthly. The poor performance is also represented by the PPM levels which indicate complete non-conformance to VOC and a non-capable process. Since the process is in control, we moved onto a Capability Analysis. The process is currently not capable of meeting demand. The process is in control and not capable, so it is appropriate to analyze the root causes for making changes/improvements to attain capability (both Cp and Cpk).

MRIs Completed and Costs at RACH, in the Network and Total:

Location	Min	Max	Range	Mean	Median	Std Dev
RACH	130	200	70	167.6	165.5	20.5
Network	165	317	152	246.5	247	40.4
Total	333	478	145	414.1	414.5	44.9

Table 2. Descriptive Statistical Analysis of MRIs completed monthly at RACH, in the Network and Total

Descriptive statistical analysis of the 28 monthly totals of MRIs completed at RACH showed a minimum of 130, maximum of 200, range of 70, mean of 167.6, median of 165.5 and a standard deviation of 20.5.

Descriptive statistical analysis of the 28 monthly totals of out-patient, non-emergent MRIs completed at in the network on younger than 65 years-old showed a minimum of 165, maximum of 317, range of 152, mean of 246.5, median of 247 and a standard deviation of 40.4.

Descriptive statistical analysis of the 28 monthly totals of MRIs completed at RACH and in the network combined showed a minimum of 333, maximum of 478, range of 145, mean of 414.1, median of 414.5 and a standard deviation of 44.9.

The chart below (Figure 8) depicts the monthly totals of MRIs completed at RACH, in the Network and the combined Total from Oct 06 – Jan 09. It is apparent that the MRIs completed at RACH have remained relatively constant with much less variation compared to the Network and Total MRIs which are trending higher with more variation.

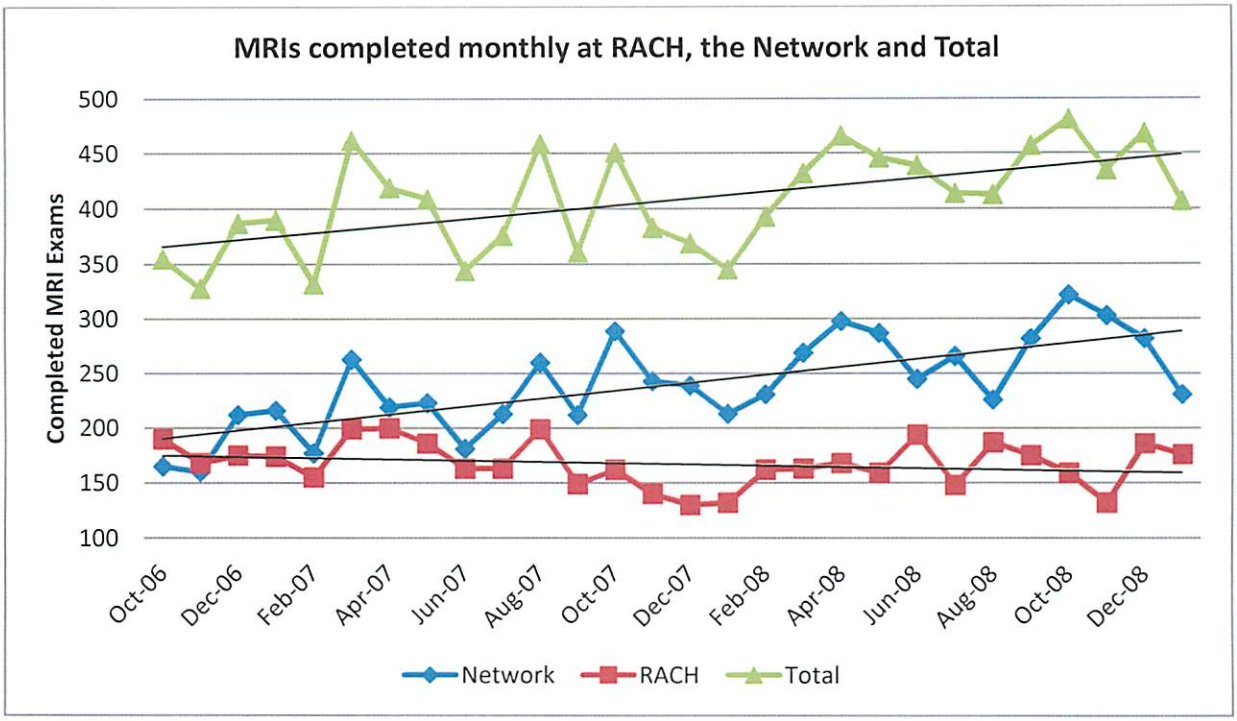


Figure 8: MRIs Completed Monthly at RACH, the Network and Total (Oct 06 – Jan 09)

In FY 2008, the network accounted for 63% of the MRIs in the RACH catchment area and 69% of the cost. On average, each network MRIs cost $101.26 more than MRIs completed at RACH.

	FY 2008 Actual				
	MRI's Completed	% MRI	Cost	% Cost of Total	Avg Cost Per MRI
Network	3,219	63%	$1,400,000	69%	$434.91
RACH	1,920	37%	$640,600	31%	$333.65
Total	5,139	100%	$2,040,600	100%	$397.08

Table 3. Production and Cost Comparison between the Network and RACH in FY 08

RACH costs include $80 per MRI for the reading. Network costs also include the cost of the reading. The plan for 2008 was to complete 2,651 MRIs at RACH at a total cost of $699,080. The planned average cost per completed MRI at RACH was $263.70, which was $171.21 less expensive than Network MRIs.

Takt Time Analysis:

In FY2008, RACH completed 1,920 MRIs over the course of 242 clinic days which equates to an average of 7.93 MRIs per day. If RACH had completed an average of 21.23 MRIs per clinic day in FY 08, they could have completed all 5,139 MRIs at RACH. As stated previously, RACH contracted for an MRI trailer for nine hours per clinic day. There are approximately 241 clinic days per year (FY 08 was a leap year, so there were 242 clinic days that year). Each year, clinics are closed on weekends (104 days), federal holidays (10 days) and training holidays (10 days). If there were zero defects in their MRI process, all 5,139 MRIs could have been completed at RACH if the average process cycle time was 25.2 minutes. Takt time is the process cycle time required to complete 100% of the work without any backlogs or waste. These calculations ignore the fact that you cannot do a portion of an MRI one day and complete the MRI the next clinic day.

4.0 Analyze

The Takt time calculation revealed that we would need to decrease our process cycle time (MRI exam times) to 25.2 minutes without any defects. A sampling of other hospitals, imaging centers, and subject matter experts revealed that the best run MRIs utilizing a top of the line MRI, equipment, and expert staff could hope to achieve a defect rate of 5% and a process cycle

time of 25 minutes. However, it is unlikely for them to perform at that level every month.

Defects:

As previously stated, during the 28 month baseline period, a total of 6,194 MRI appointments were available for booking at RACH; 4,694 MRI exams were actually completed and 1,500 appointments were wasted. The Completion Rate (CR) was 75.8% and the defect rate was 24.2%. This equates to 242,170 Defects Per Million Opportunities (DPMO) and a Sigma Quality Level of 2.20. The Monthly Productivity Report (Table 1) breaks down the 24.2% defect rate in the "Total" row at the bottom of the table. The defect rate is broken down between: Un-Booked (UB) 9.2%, No-Show (NS) 9.2%, Equipment Down (ED) 2.9%, Last Minute Cancel (LMC) 2.2%, Claustrophobic Patient (CP) 0.6% and Contraindication (CI) 0.2%. For the baseline period, No-Shows and Un-Booked appointments account for 18.4% of the 24.2% defect rate. A histogram of the 1,500 defects is the best way to show the disproportionate amount of waste resulting from No-Shows and Un-Booked Appointments.

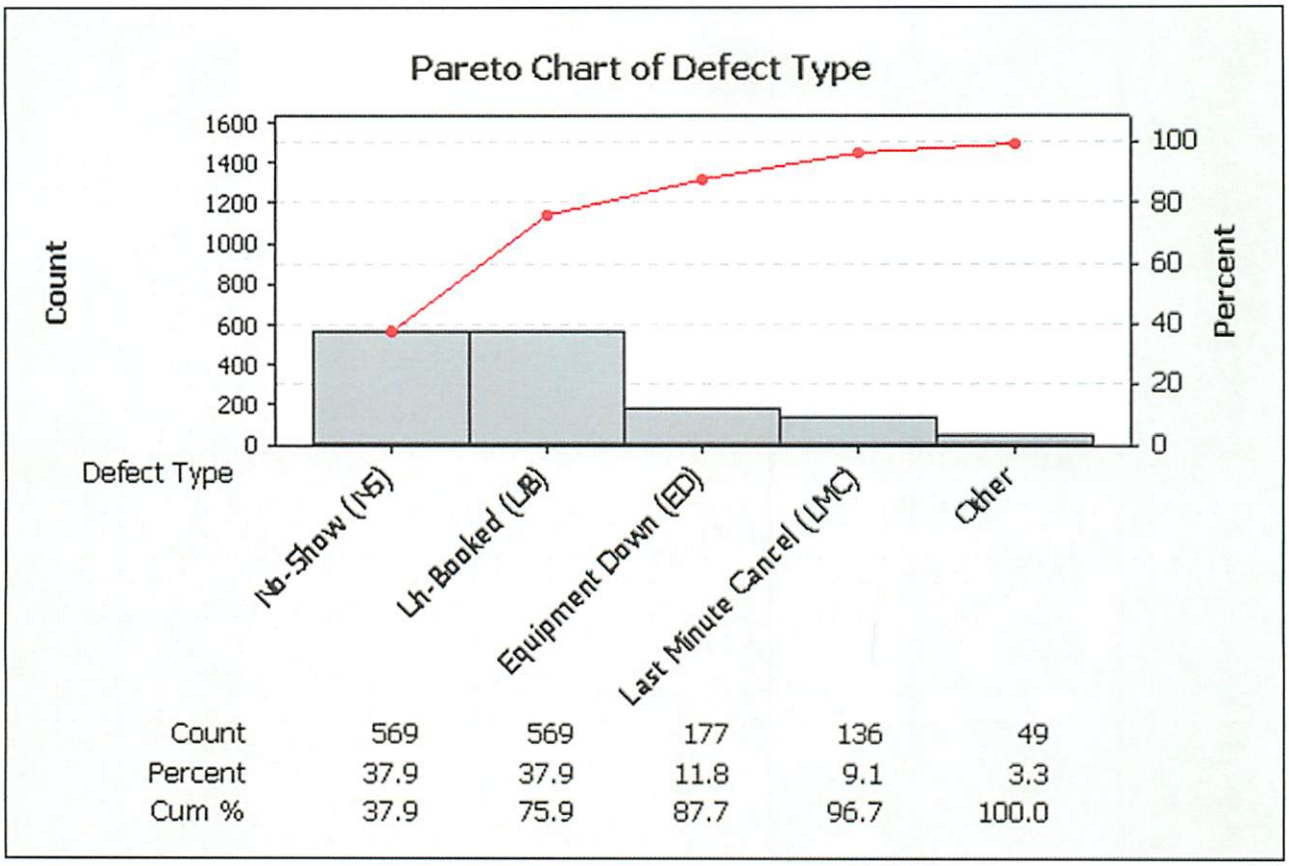


Figure 9: Non-completed MRI exams

No-Shows and Un-Booked appointments account for 75.9% of all defects. Eliminating NS and UB appointments would have resulted in 1,138 more completed MRI exams to RACH, and would have saved approximately $404,000 in expenses. Therefore, this project will focus on decreasing No-Shows and Un-Booked appointments and accept the current performance in the other four categories of waste. It is worth noting that the percent waste for each of the categories of waste equals the number of wasted appointments divided by the number of ***AVAILABLE*** appointments (6,194). The common definition of the no-show rate equals the number of no-shows (569) divided by the number of ***BOOKED*** appointments (5,625) or 10.1%. Thus, when there are un-booked appointments, the definition of no-shows in this study actually understates

the no-show rate compared to the commonly defined no-show rate.

Goals:

Recall that the operational goals were to: increase the number of completed MRI appointments per month at RACH by 50%, and reduce both the no-show rate and un-booked appointment rate by 20% each. An increase of 50% MRI production at RACH over the baseline would increase the number completed MRIs from 2,004 MRIs per year to 3,006 MRIs completed at RACH per year. A 20% decrease in No-Shows and Unbooked appointments would decrease the defect rate from 24.2 % to 20.5%. Therefore, in order to complete 3,006 MRIs pear year at RACH, approximately 3,782 available appointments are required. Table 4 below summarizes this data and compares the DPMO and sigma level of the baseline data and the operational goals of this project.

DPMO and Sigma Quality Level		
	Baseline	**Annual Goal**
OU (# Opportunities for Defects in one **Unit)**	1	1
# Units sampled	6194	3782
# Defects in all units sampled	1500	776
Defect Rate (# Ds / # Us)*100%	24.2%	20.5%
DPMO (DPU/OU)*1,000,000 **Os**	**242,170**	**205,182**
Sigma Level	**2.2**	**2.36**

Table 4. DPMO and Sigma Quality Level

Cause and Effect Diagram and Root Cause Analysis:

A Cause and Effect Diagram, which specifies which critical inputs (X's) cause the output (Y) effect, is displayed in the figure below.

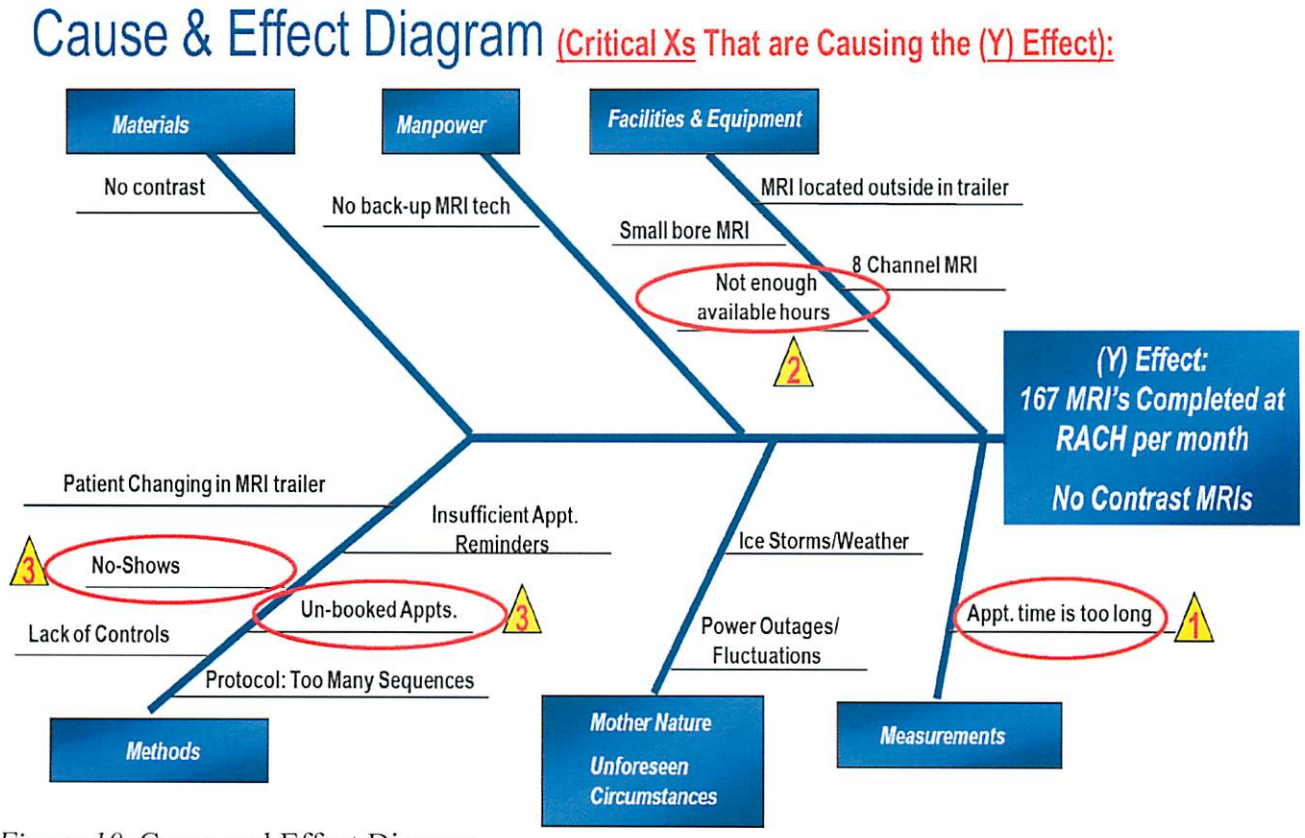


Figure 10. Cause and Effect Diagram

The root causes of the problem were: appointments were too long, not enough available hours of operation, too many no-shows and un-booked appointments. Patient throughput was the first inefficiency discovered.

Prioritized Root Causes

Effect (Y)	Root Cause (X)	Priority
Only 11 Appts Avail / day	Long Appointment Length (45 min)	High
Wasted Appts	High No-Show Rate (10.1%)	Med
Wasted Appts	High Un-Booked Rate (9.2%)	Med
Only 55 Appts Avail / week	MRI Contract (45 hrs / week)	Med
No MRIs w/ Contrast	Misunderstanding of the Contract	Low

Figure 11. Prioritized Root Causes

Two MRI clinics in Oklahoma scheduled patients for approximately 30-35 minutes per MRI, while appointments at RACH were 45 minutes. The MRI scan itself is the primary value added step for the patient. It is also the rate limiting step because it is the only step that requires the patient, MRI technician, and MRI trailer. Focus should be given to minimizing the amount of time that the MRI machine is not being used to scan patients (turnover time between patients) and to minimize the length of time it takes to scan each patient.

Proposed Quick Wins

- Change the Protocols , Shorten Appointment Time, Increase Appointments per day

Completed Quick Wins

- Changed the Protocols to reduce the series of images required for each MRI
- Decreased Appt Time by 10 minutes (45 to 35)
- Added three Available Appointments / day (11 to 14)

5.0 Improve

The fourth phase of the DMAIC process is the Improve phase. In the improve phase, the team developed potential solutions, narrowed those down to the best solutions, and then developed a new process map incorporating the best solutions. The primary focus was to increase patient throughput to increase direct care capacity and workload. The primary solutions were: decrease appointment times by changing the business processes, decrease no-shows by calling and reminding patients of their appointment, extend hours by modifying the contract, and expanding the types of MRIs offered to decrease un-booked appointments.

Three main changes were proposed to decrease appointment lengths: shorter MRI protocols, contract MRI technicians asking patients if there are any contraindications while escorting them to the MRI trailer, and reducing the number of patients that need to change in the MRI trailer to prepare for their appointment. An MRI protocol is a list of the image sequences that should be taken for each type of MRI. Radiologists work with the MRI technicians to determine which imaging sequences they prefer for diagnosing each type of MRI. MAJ (Dr.) Stinson determined that he could provide a diagnosis of equal quality with fewer and or shorter sequences.

Evaluation of Potential Solutions

	Criteria 1: ROI	Criteria 2: Time/Effort Required	Criteria 3: Meets Customer Requirements	Total Score
Weight	10	5	3	
Decrease Appt Length	10	4	2	16
Extend the hours of Operation	8	1	3	12
Appt Reminder Phone Calls	6	3	2	11
Minimize Un-Booked Appts	6	3	1	10
Perform MRIs w/ Contrast	4	3	1	8
Radiologist Review Referrals	4	1	2	7
Radiology Staff Member Schedule Pts	2	2	1	5

Table 5. Evaluation of Potential Solutions

Prioritized list of Solutions

Priority	Solutions
1	Decrease Appt Length: Change MRI protocols to reduce the number of series of images required for each procedure (decreases scan time); When scheduling the MRI Tell Patient to wear MRI friendly clothes; Have Pt Change into MRI friendly clothes in Rad Dept instead of in the MRI Trailer; Ask Pt about contraindications while walking to the MRI trailer; Change schedule from 45 min appt to 35 and from 11 appts per day to 14.
2	Extend Hours of Operation: Modify the contract from 45 hours/week to 63. Open 11 hours Mon-Fri and 8 hours on Sat.
3	Decrease Defects (Waste) from No-Shows: Have a staff member make appt reminder phone call to each pt the day before the appt

Figure 12. Prioritized List of Solutions

The new process chart (Figure 13) below shows the changes in red. Notice that the patient is asked if they have any contraindications while being escorted to the MRI trailer, instead of answering the questions inside and then escorted to the trailer. Additionally the patient is reminded twice to wear MRI appropriate clothing to the appointment or bring the clothing to the appointment and change before the actual appointment time. Patients have always been told to arrive 15 minutes early, but it was not appropriate to have them change into a gown, wait for their appointment and walk outside to the MRI trailer in a gown. Now patients do not have to change or they change inside the Radiology Department without wasting valuable time in the MRI trailer.

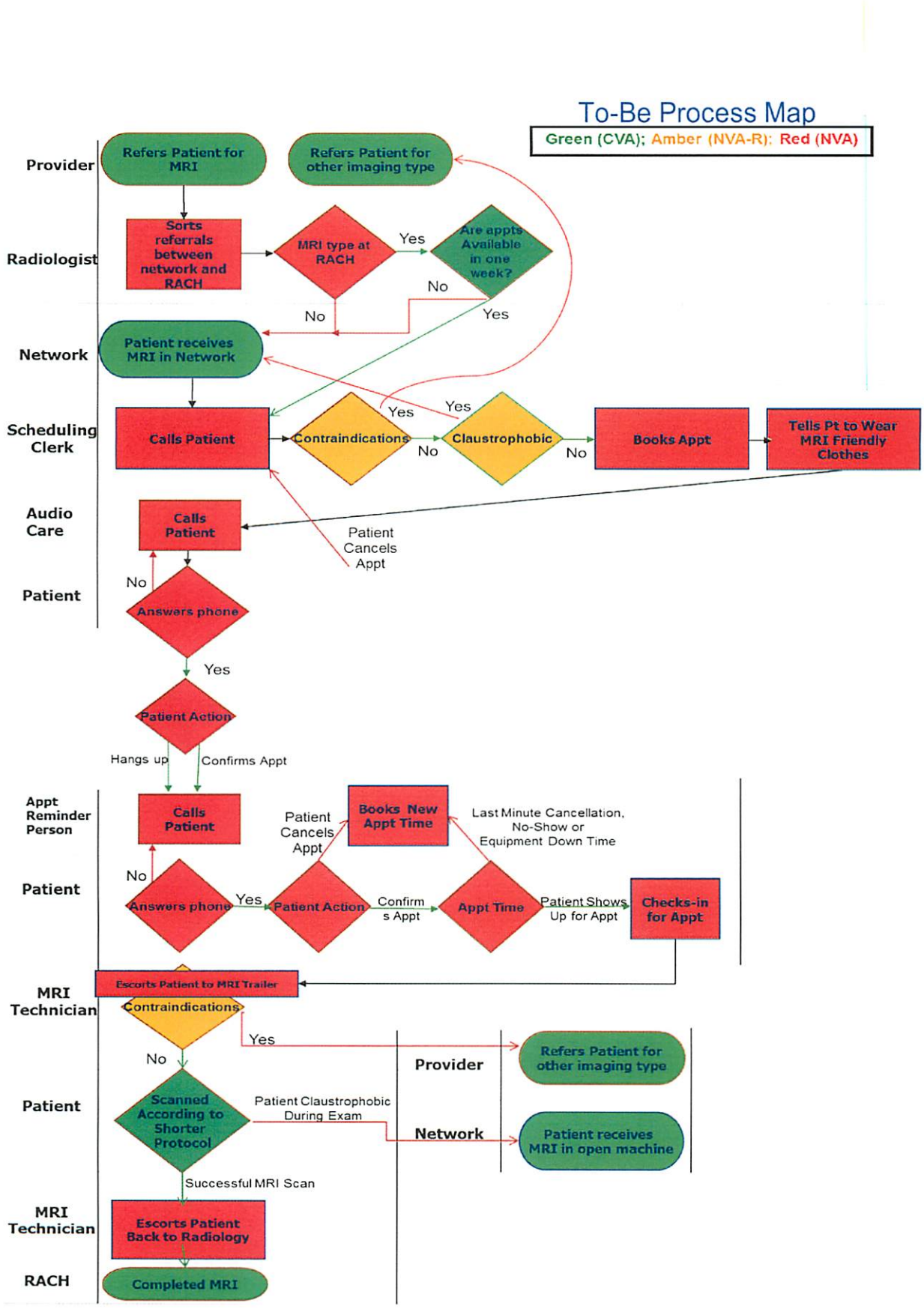


Figure 13: Improved process chart

1. Decreased appointment lengths. The MRI appointments were reduced from 45 to 35 minutes effective 15 Jan 09, resulting in an increase from 11 to 14 appointments in a nine hour shift. Based on 242 days of MRI clinic per year, the shortened appointments should result in 550 more completed MRIs at RACH per year. At an average cost of $435 per MRI * 550 additional exams = $239,384 reduction in expenditures on network MRIs by TMA. The mean number of MRI appointments available and completed increased by 30.1% (67) and 45.8% (76) respectively. The chart (Table 6) below shows that the improvement was extremely successful.

Increase of MRI completed appointments

Oct 06 - Jan 09	Mean # Appts Available / Month	222		
Oct 06 - Jan 09	Mean # of MRIs Completed / Month	167	Increase from Oct 06 - Jan 09	
Feb - Apr 09	Mean # Appts Available / Month	289	67	30.1%
Feb - Apr 09	Mean # of MRIs Completed / Month	243	76	45.8%

Table 6. Increase of MRI Completed Appointments

2. Decrease the Patient No-Show Rate. A significant improvement in the no-show rate was a result of adding a control to the MRI process. It is important to document the control with a policy and or change in duty description. In mid-March, Ms. Lori Leal started calling patients the day before their appointment. The no-show rate decreased to 2.7% during the period Ms. Leal called to remind the patients. However, in April she became busy and only called a couple of days and then stopped calling when she went on leave. Without the additional control, the no-show rate returned to 7.1% during April. In May, the contractor, Ms. Nancy Washburn, started calling the patients again and the no-show rate decreased to 1.6%. Ms. Washburn made arrangements for someone to call the patients during her absence for the first two weeks of June.

Ms. Washburn started calling the patient the day prior to the exam to reduce no-show rates. Although this adds an additional step to the process, she has been able to accomplish this

task without slowing patient throughput. This is possible because the contract requires two MRI technicians to work each day. This resulted in a decrease of waste as shown on the chart (Figure 14) below. Specifically, no-shows decreased from 9.2% from Oct 06 – Jan 09 to 4.1% from Feb – May 09. More details are provided on the transition to the contractor calling in the Control section. Interestingly, last minute cancelations increased from 2.2% to 3.2%, and it is hypothesized that is a result of more people remembering they have the appointment, so they call and cancel when they realize they cannot make it. It could also be a result of the social contract established by having the person providing the care reminding the patient of their appointment. The patient now feels more committed to fulfilling their obligation to show-up for their appointment or at least call and cancel, even if it is at the last minute instead of simply no-showing for their appointment. Another advantage of having the MRI technician call the patient is that they can answer the patient's questions if they have any. Of course that is only if the patient answers the phone. One subtle difference between the AudioCare appointment reminder phone call and the contractor's, is that AudioCare does not leave a message with the appointment time; the contractor leaves a message with the appointment time and the reminder to wear MRI friendly clothing.

3. Extend the hours of the MRI contract at RACH. The MRI contract was extended by 18 hours a week. Effective 2 May 09, the MRI trailer is open two hours longer in the evening Monday – Friday and open on Saturday for 8 hours. This change resulted in four additional appointments each weekday and 11 appointments on Saturday. The MRI trailer is open every Saturday, to include holiday weekends (unless Saturday is the actual federal holiday). If the MRI contract is extended beyond FY10, the statement of work should be changed so the MRI trailer is open on training holidays. The monthly available and completed MRIs improved

starting in Feb 09 compared to the baseline data. There was a dramatic increase of available appointments in May 09; however the increase of completed appointments was less pronounced. This is better quantified in Table 7 below.

Oct 06 - Jan 09	Mean # Appts Available / Month	222				
Oct 06 - Jan 09	Mean # of MRIs Completed / Month	167	Increase from Oct 06 - Jan 09			
Feb - Apr 09	Mean # Appts Available / Month	289	67	30.1%		
Feb - Apr 09	Mean # of MRIs Completed / Month	243	76	45.8%	Increase from Feb - Apr 09	
May 09	# MRIs Available / Month	432	210	94.3%	143	49.3%
May 09	# of MRIs Completed / Month	312	145	86.9%	69	28.2%

Table 7. Increase of completed MRIs

Compared to the average from Feb – Apr 09, the extended hours added 143 available appointments in May, but only 69 more completed MRIs. The chart (Table 8) below shows the annual and monthly cost of the contract modification to extend the hours. Dividing $17,667 by the 69 additional appointments equals a marginal cost of $256 for the extended hours. Although this is still a savings compared to purchasing the appointments in the network it is well above the average cost per exam of $167 from Feb – Apr 09.

$212,000	Annual Cost for Extended Hours
$17,667	Monthly Cost for Extended Hours
$256	Marginal Cost / Exam in May from Extended Contract
$243	Oct 06 - Jan 09 Cost/Exam
$167	Feb - Apr 09 Cost / Exam
$187	Average Cost/Exam May

Table 8. Annual and monthly cost of contract modification

6.0 Control

The fifth phase of LSS DMAIC process is Control. The goal of the control phase is to monitor performance and implement procedures to ensure long term success of the process owner. Additionally, small adjustments and improvements can be implemented. Table 9 below outlines the plan to transfer the management of the process back to the process owner.

Step	Action/Task	Responsible	Accountable	Consulted	Informed
1	Present Productivity Report to BOD Monthly	Rad Administrator	Chief Rad	MRI Techs	BOD
2	Review MRI Protocols	Chief Rad	Chief Rad	Radiologists	MRI Techs
3	Pt Wear MRI Friendly Clothes	Scheduling Clerk	MRI Tech	MRI Techs	All
4	Pt Change Clothes in Rad	Rad Front Desk Clerks	MRI Tech	Rad NCOIC	All
5	Contraindications	MRI Techs	MRI Techs	Chief Rad	All
6	Review Templates	Rad Admin	Rad Admin	MRI Tech	Chief Rad
7	Appt Reminder Phone Calls	MRI Techs	Rad Admin	Rad Chief	All
8	Supervise MRI Contract	Managed Care	Rad Admin	Rad Chief	All
9	Optimize Scheduling	Medical Mgmnt	Chief Rad	Rad Admin	All

Table 9. The Plan to Transfer Management Back to the Process Owner.

A visual control chart is a key tool for the process owner to measure and maintain accountability and success of the process. The MRI Productivity Report FY10 (Table 10) is the visual control chart used to measure monthly performance.

MRI Productivity Tracking FY'10																
Month	FY	Total slots avail	Actual Scheduled	%	No-Show	%	Re-schedule	%	Equipment Down	%	Claustro-phobic	%	Contra indication	%	Actual Exams done	%Productivity
Oct	2010	394	407	103%	14	3.4%	12	2.9%	0	0.0%	1	0.2%	1	0.2%	397	96.2%
Nov		339	356	105%	15	4.2%	16	4.5%	7	2.0%	2	0.6%	2	0.6%	314	88.2%
Dec		376	311	83%	9	2.9%	13	4.2%	37	11.9%	2	0.6%	0	0.0%	250	80.4%
Jan		350	350	100%	12	3.4%	40	11.4%	116	33.1%	3	0.9%	0	0.0%	234	51.1%
Feb		356	356	100%	18	5.1%	38	10.7%	12	3.4%	1	0.3%	1	0.3%	286	80.3%
Mar		435	432	99%	26	6.0%	10	2.3%	30	6.9%	5	1.2%	2	0.5%	359	83.1%
Apr		418	432	103%	21	4.9%	10	2.3%	16	3.7%	0	0.0%	0	0.0%	385	89.1%
May		378	387	102%	28	7.2%	11	2.8%	0	0.0%	1	0.3%	1	0.3%	346	89.4%
Jun		418	432	103%	35	8.1%	13	3.0%	69	16.0%	2	0.5%	2	0.5%	311	72.0%
Jul		395	397	101%	29	7.3%	19	4.8%	0	0.0%	5	1.3%	1	0.3%	343	86.4%
Aug		418	413	99%	36	8.7%	22	5.3%	0	0.0%	2	0.5%	1	0.2%	352	85.2%
Sep		384	375	98%	26	6.9%	3	0.8%	0	0.0%	1	0.3%	0	0.0%	345	92.0%

Table 10. MRI Productivity Report FY 10.

Table 11 lists the specification limits, reaction plan,

and responsible individual for each of the metrics in the MRI productivity report.

			Applicable Control Charts and Metrics						
Item #	Controlled Input, Process, or Output Metric (X or Y) to be Monitored	Responsible Individual	Freq.	Process Step	Target Value	Upper Spec Limits	Lower Spec Limits	Current	Reaction Plan
1	Total Appts Avail	Rad Admin	Monthly	Schedule Opened	375	500	350	384	Review Templates
2	% Appt Scheduled	Medical Mgmnt	Monthly	Appt Booked	98%	100%	95%	98%	C, Rad Mtg w/ C, Med Mgmnt
3	% No-Show	MRI Tech	Monthly	Pt Shows / no-show	5%	0%	8%	7%	Rad NCOIC Mtg w/ MRI Techs
4	% Equipment Down	MRI Contractor	Monthly	Calibration	2%	0%	5%	0%	COR meets with MRI Contractor
5	% Last Minute Cancel	Rad Admin	Monthly	Pre-appt	2%	0%	5%	1%	Rad Admin interviews LMC Pts
6	% Claustrophobic	Medical Mgmnt	Monthly	During MRI	1%	0%	2%	0%	Rad Admin interviews Claus Pts
7	% Contraindication	Medical Mgmnt	Monthly	Pre-MRI questionaire	0.20%	0%	0.60%	0%	Retrain Med Mgmnt Appt Schedulers
8	Completed Exams	Rad Admin	Monthly	Exam Completed	400	500	350	345	C, Rad meets with Rad Admin
9	% Productivity	Rad Admin	Monthly	Exam Completed	90%	100%	83%	92%	C, Rad meets with Rad Admin

Table 11. Control Chart

Results:

The Solution Achieved the Project Goals

Project Goals

Operational: Increase the # of MRIs completed at RACH from 167 to 251, an increase of 50%. (Actually Achieved: 327 completed MRIs / month = 96% increase).

Financial: Reduce the avg cost / completed MRI at RACH from $334 to $301, a decrease of 10%. (Actually Achieved: $258 / completed MRI at RACH a decrease of 23%).

FY 2009 Partial (Feb - Sep 09): Quick Wins were implemented in Feb 09 & Extended hours contract started in May 09								
Month	Direct Care MRIs Completed	Additional MRIs Completed (increase over baseline)	Average amount Pd per network MRI in FY 09	Avoided Network Care Payments b/c of Increase over baseline	Cost to Read additional MRIs ($80 per MRI)	Increased Cost of MRI Contract	Total Increased Direct Care Costs	**Net Savings**
Feb-09	234	67	$ 458	$ 30,686	$ 5,360	0	$ 5,360	**$ 25,326**
Mar-09	267	100	$ 458	$ 45,800	$ 8,000	0	$ 8,000	**$ 37,800**
Apr-09	229	62	$ 458	$ 28,396	$ 4,960	0	$ 4,960	**$ 23,436**
May-09	312	145	$ 458	$ 66,410	$ 11,600	$ 17,667	$ 29,267	**$ 37,143**
Jun-09	289	122	$ 458	$ 55,876	$ 9,760	$ 17,667	$ 27,427	**$ 28,449**
Jul-09	366	199	$ 458	$ 91,142	$ 15,920	$ 17,667	$ 33,587	**$ 57,555**
Aug-09	363	196	$ 458	$ 89,768	$ 15,680	$ 17,667	$ 33,347	**$ 56,421**
Sep-09	352	185	$ 458	$ 84,730	$ 14,800	$ 17,667	$ 32,467	**$ 52,263**
Total	**2412**	**1076**	**$ 458**	**$ 492,808**	**$ 86,080**	**$ 88,335**	**$ 174,415**	**$ 318,393**

Table 12. Quick Wins.

Baseline ~1336 Direct Care MRIs would have been completed From Feb – Sep 09 (8 months x 167 MRIs / Month) . Improvements Resulted in the completion of 2,412 Direct Care MRIs = 1,076 increase over the baseline. Each additional direct care MRI results in $80 of additional direct care costs to read the MRI. Extended hours contract increased direct care costs by $17,667 / month starting in May 2009. Average amount paid per network MRI in FY 09 = $458

Avoided Purchased Care Costs = $492K . Additional Direct Care Costs = $174K. Net Savings = $318K.

FY 2010								
Month	Direct Care MRIs Completed	Additional MRIs Completed (increase over baseline)	Average amount Pd per network MRI in FY 10	Avoided Network Care Payments b/c of Increase over baseline	Cost to Read additional MRIs ($80 per MRI)	Increased Cost of MRI Contract	Total Increased Direct Care Costs	**Net Savings**
Oct-09	397	230	$ 442	$ 101,660	$ 18,400	$ 17,667	$ 36,067	$ 65,593
Nov-09	314	147	$ 442	$ 64,974	$ 11,760	$ 17,667	$ 29,427	$ 35,547
Dec-09	250	83	$ 442	$ 36,686	$ 6,640	$ 17,667	$ 24,307	$ 12,379
Jan-10	234	67	$ 442	$ 29,614	$ 5,360	$ 17,667	$ 23,027	$ 6,587
Feb-10	286	119	$ 442	$ 52,598	$ 9,520	$ 17,667	$ 27,187	$ 25,411
Mar-10	359	192	$ 442	$ 84,864	$ 15,360	$ 17,667	$ 33,027	$ 51,837
Apr-10	385	218	$ 442	$ 96,356	$ 17,440	$ 17,667	$ 35,107	$ 61,249
May-10	346	179	$ 442	$ 79,118	$ 14,320	$ 17,667	$ 31,987	$ 47,131
Jun-10	311	144	$ 442	$ 63,648	$ 11,520	$ 17,667	$ 29,187	$ 34,461
Jul-10	343	176	$ 442	$ 77,792	$ 14,080	$ 17,667	$ 31,747	$ 46,045
Aug-10	352	185	$ 442	$ 81,770	$ 14,800	$ 17,667	$ 32,467	$ 49,303
Sep-10	345	178	$ 442	$ 78,676	$ 14,240	$ 17,667	$ 31,907	$ 46,769
Total	**3922**	**1918**	**$ 442**	**$ 847,756**	**$ 153,440**	**$ 212,004**	**$365,444**	**$ 482,312**

Table 13.

Baseline ~2,004 Direct Care MRIs would have been completed in FY10 (12 months x 167 MRIs per Month). Improvements Resulted in the completion of 3,922 Direct Care MRIs = 1,918 increase over the baseline. Each additional direct care MRI results in $80 of additional direct care costs to read the MRI. Extended hours contract increased direct care costs by $17,667 per month. Average amount paid per network MRI in FY 10 = $442. In FY 10, RACH invested an addition $365K in direct care, resulting in $848K in avoided Purchased Care Costs = $482K

DPMO and Sigma Quality Level Calculator

	Baseline	Results
OU (# Opportunities for Defects in one Unit)	1	1
# Units sampled	6194	4661
# Defects in all units sampled	1500	739
DPU (# Ds / # Us)	0.2422	0.1585
DPMO (DPU/OU)*1,000,000Os	242,170	158,550
Sigma Level	2.20	2.50

Percent Change in DPMO: -35%

Percent Change in SQL: 14%

Table 14. DPMO and Sigma Quality Level Calculator

Additional improvements identified and implemented during the control phase:

Start performing MRIs with contrast and Magnetic Resonance Angiograms (MRA)s at RACH. As discussed in the Define phase of this report, only those MRIs with CPT codes highlighted in purple (Figure 14) are performed at RACH. Radiology has ordered contrast and a new process is planned to start the IV in Radiology in order to minimize the time in the MRI trailer. Contrast appointments take longer, so some appointments in the new appointment template are 40 minutes to provide enough time to complete the exam. The new template was implemented 2 May 2009, the same date the MRI hours were extended. Therefore, RACH should not decrease the number of available appointments per day when they start performing

MRIs with contrast. The code procedures were also updated to include the contingency of a patient who has a reaction to the contrast. Finally, changes were made to schedule MRIs at RACH also. Those changes will allow all of the exams highlighted in yellow (Figure 14), with the exception of breast MRIs (in bold font) to be completed at RACH.

CPT Code	Description	# Completed	Amount Paid	Average Cost
73721	MRI Lower Extremity Joint w/o Contrast	784	$295,974	$378
70553	MRI Head w/o & w/ Contrast	298	$201,620	$677
72148	MRI Lumbar Spine w/o Contrast	515	$193,091	$375
73221	MRI Upper Extremity Joint w/o Contrast	394	$150,125	$381
70551	MRI Head w/o Contrast	300	$111,734	$372
72141	MRI Cervical Spine w/o Contrast	313	$111,067	$355
72158	MRI Lumbar Spine w/o & w/ Contrast	120	$78,240	$652
70543	MRI Face, Orbit, Neck w/o & w/ Contrast	86	$61,541	$716
72146	MRI Thoracic Spine w/o Contrast	95	$34,816	$366
72156	MRI Cervical Spine w/o & w/ Contrast	42	$28,164	$671
70544	MRA Head w/o Contrast	54	$20,464	$379
73718	MRI Lower Extremity w/o Contrast	38	$15,883	$418
77059	**MRI Breast Bilateral w/o & w Contrast**	**21**	**$12,947**	**$617**
73723	MRI Lower Extremity Joint w/o & w/ Contrast	17	$11,843	$697
74183	MRI Abdomen w/o & w/ Contrast	17	$11,258	$662
72195	MRI Pelvis w/o Contrast	25	$10,935	$437
72157	MRI Thoracic Spine w/o & w contrast	14	$10,307	$736
72197	MRI Pelvis w/o & w Contrast	9	$7,673	$853
73720	MRI Lower extremity w/o & w/ Contrast	10	$5,927	$593
73223	MRI Upper Extremity Joint w/o & w/ Contrast	5	$3,138	$628
70548	MRA Neck w/ Contrast	8	$2,673	$334
73218	MRI Upper Extremity w/o Contrast	8	$2,504	$313
74181	MRI Abdomen w/o Contrast	6	$2,492	$415
70549	MRA Neck w/o & w/ Contrast	3	$2,372	$791
73222	MRI Upper Extremity Joint w/ Contrast (Arthrogram)	10	$2,347	$235
70546	MRA Head w/o & w/ Contrast	3	$2,118	$706
70552	MRI Head w/ Contrast	4	$1,908	$477
72142	MRI Cervical Spine w/ Contrast	3	$1,821	$607
72147	MRI Thoracic Spine w/ Contrast	2	$1,633	$816
73220	MRI Upper Extremity w/o & w/ Contrast	6	$1,066	$178
70540	MRI Face, Orbit, Neck w/o Contrast	3	$841	$280
74185	MRA Abdomen w/ or w/o Contrast	2	$511	$256
71550	MRI Chest w/o Contrast	1	$438	$438

73722	MRI Lower Extremity Joint w/ Contrast	2	$158	$79
70336	MRI TMJ	1	$116	$116
	Grand Total	**3219**	**$1,399,745**	**$435**

Figure 14: MRIs and MRAs now available at RACH

Put the Radiologist in charge of reviewing referrals. Anecdotally, it was reported that many referrals being sent to the network could have been completed at RACH. Ms. Washburn was a MRI technologist at Southwestern Medical Center, one of the network MRI providers in Lawton. She stated that most of the referrals they received from RACH were for MRIs with contrast. However, 90% of those did not need contrast, so the patients received an MRI without contrast. Those MRIs without contrast could have all been booked at RACH, decreasing the 9.2% waste from Un-booked appointments. Although contrast MRIs will soon be available at RACH, there is still a benefit to having the Chief of Radiology review the referrals.

Dr. Stinson felt that it would provide him with better visibility and operational control of the MRI process and minimize leakage to the network. He stated that it would be too complex to write an algorithm for the Referral Management nurse and it requires his expertise as a radiologist to make the changes to the referrals. Reviewing the referrals would naturally lead to another LSS project on utilization management of MRIs. This would probably require the involvement of the orthopedic doctors, as they are often the providers that the patient is being sent to with a completed MRI. As mentioned in the define phase of the project, that is outside of the scope of this project, however, this is an extremely important next step because the MRI utilization rate grew by an average of 17% per year from FY 05 to FY 08. The problem statement of this project, "to decrease TMA's cost by 80%" is only possible if RACH implements a better utilization management process and educates its referring providers.

6. Recapture MRI referrals made by network providers. MRI referrals made by network providers are automatically sent to Humana and routed to the network. RACH has the option to tell Humana that they want the Right of First Refusal (ROFR) for MRI referrals. That would give RACH the opportunity to review all MRI referrals made by network providers and recapture those MRIs that can be provided at RACH within 28 days. One caveat to this recommendation, it should only be implemented if RACH fails to achieve its goal of 3% or less of Un-Booked appointments after the other improvements are completed, otherwise RACH risks creating unnecessary work, for a limited reward.

Acquire a fixed MRI within RACH.

A new 1.5 Tesla, 18 channel MRI in the radiology department would be more efficient and provide clearer, more detailed images than the leased MRI. The new MRI automates routine processes making them faster and simpler. Patient throughput will improve by situating the MRI right behind the Radiology department front desk, constructing two changing rooms and a waiting area next to the MRI machine. MRI appointments are currently 35 minutes long; however, using the new technology and better layout; appointments will be 30 minutes or less. Patients sent to the network have to travel 4-5 miles to the local hospitals or outpatient imaging center. This travel requirement will be eliminated. Providing all the MRIs onsite also improves continuity of care.

In February 2005, the U.S. Army Medical Materiel Agency (USAMMA) completed a Technology Assessment and Requirements Analysis (TARA) at RACH. The team recommended that RACH continue pursuing a resource sharing agreement with Humana to lease an MRI Trailer from a contractor. Next, the team recommended that RACH consider acquiring a fixed MRI if there are at least 2,400 exams per year, utilization management processes, adequate

space allocation, technologist availability and reading capability (TARA, 2005).

Situating an MRI in the facility would give RACH operational control, allowing for flexible hours of operation to meet demand and provide emergent and inpatient MRIs. In contrast, it requires a contract modification to adjust the operating hours of the leased MRI trailer. Currently, RACH substitutes other imaging modalities for inpatient or emergent MRIs; if absolutely necessary they send patients to the network to get an MRI. Finally, the new system would have a patient cart system made of non-ferrous material so a non-ambulatory patient switches beds once instead of twice as with a traditional MRI patient table.

The proposed acquisition package includes numerous 8-channel specialized coils designed for individual body parts, which decreases scan time and improves patient comfort and image quality. Also included are two breast coils (a 16-channel diagnostic coil and 7-channel biopsy coil) and a computer assisted diagnostic (CAD) system. Breast MRI has been proven to improve early detection of breast cancer and is recommended as the standard diagnostic process for women meeting additional criteria.

Finally, the new MRI has a bore that is 70 cm in diameter and only 120 cm long. This design by Siemens improves patient comfort by giving the patient more room and allows their head to be out of the bore for more than half of all scans. The design significantly reduces, if not eliminates the need to refer patients to a sub-optimal open MRI in the network. The most notable technological advantages gained are improved patient experience (the bore has a larger diameter and shorter length), motion correction, decreased use of contrast, breast imaging, speed, and image quality.

Finally, the team recommends that this LSS project should be replicated at each MTF and each iterative improvement should be shared with all the process owners. Ultimately the MHS

could consolidate the best practices and develop a prescriptive and specific policy for each MTF to follow along with a training program. A metric would be included in the Command Management System and each MTF commander would be held accountable. This same process could be adopted for each product line to reduce variance, increase efficiency and save money throughout the MHS.

References

DefenseLINK. (1996). DoD *to Demonstrate Health Care for Medicare-eligible*. Retrieved June 3, 2009 from http://www.defenselink.mil/news/newsarticle.aspx?id=41454

Military Health Systems Help Desk. (2008). System:M2. Retrieved June 3, 2009, from http://www.mhs-helpdesk.com/Pages/m2.asp

RACHOO. (2008). *RACH strategic plan 2008 – 2010*. Retrieved June 3, 2009, from https://www.intranet.rach.amedd.army.mil/Announcements/Document%20Library/RACHStrategicPlan2008-2010March2008.pdf

Appendix 1

Data Collection Plan

Performance Measure	Operational Definition	Data Source and Location	How Will Data Be Collected	Who Will Collect Data	When Will Data Be Collected	Stratification Factors	How will data be used?
Hours of MRI Availability	Number of hours MRI is available for scanning.	Contract Report of Hours Worked	Contractor will report the hours to RACH COR	Contractor will collect the data and submit to the COR	Monthly	None	Determine if the MRI is available enough
# of Available MRI Appts / Month	# MRI appointment available for booking / month	MRI Productivity Report	Contractor Maintains schedule of available appts	Contractor	Daily, consolidated monthly	Arthogram Appts	Determine if there is enough capacity
# of MRIs Completed / Month	Appointments that result in completed MRIs with no defects / month.	MRI Productivity Report	Contractor Keeps track of completed appts	Contractor	Daily, Consolidated Monthly	Arthogram Appts & Body Part Scanned	Determine if sufficient workload is completed
Average Appt Length (minutes)	Mean Length Appt (Minutes)	CHCS	Data pull of CHCS	Radiology Dept Admin	Monthly	Arthrogram, Contrast, Body Part	Efficiency
MRI Contract Cost / Month	Cost of MRI contract with Docside Imaging / month	COR Payment to Contractor	COR Records when they pay the contractor	COR	Monthly	Month & Yr	Cost
Cost per Completed MRI	(Monthly cost of MRI contract / # of completed MRIs) + $80	COR Report &MRI Productivity Report	N/A Calculated from previous data	LSS Belt	Monthly	Month & Yr	Efficiency
Booked Appts	An available MRI appointment booked with a patient.	MRI Productivity Report	Contractor Maintains schedule of booked appts	Contractor	Daily, consolidated monthly	Arthogram Appts	Determine if there is waste
Un-Booked Appts	All available appointments that are not booked.	MRI Productivity Report	Contractor Maintains Daily Report	Contractor	Daily, consolidated monthly	Month & Yr	Waste
Last Minute Cancel	A booked appointment canceled by the patient but it is not re-booked.	MRI Productivity Report	Contractor Maintains Daily Report	Contractor	Daily, consolidated monthly	Month & Yr	Waste
Kept Appts	An appointment in which the scheduled patient shows up.	MRI Productivity Report	Contractor Maintains Daily Report	Contractor	Daily, consolidated monthly	Month & Yr	Efficiency
No-Show	When the patient does not show-up for their booked appointment.	MRI Productivity Report	Contractor Maintains Daily Report	Contractor	Daily, consolidated monthly	Month & Yr	Waste
Equipment Down	An appointment that is canceled or aborted due to equipment failure, loss of electricity or equipment upgrade or service.	MRI Productivity Report	Contractor Maintains Daily Report	Contractor	Daily, consolidated monthly	Month & Yr	Waste
Contraindication	An appointment that is not initiated for medical/safety reasons.	MRI Productivity Report	Contractor Maintains Daily Report	Contractor	Daily, consolidated monthly	Month & Yr	Waste
Claustrophobic	An appointment that is aborted due to the patient's inability to remain still in a confined space for the duration of the exam.	MRI Productivity Report	Contractor Maintains Daily Report	Contractor	Daily, consolidated monthly	Month & Yr	Waste
Un-Booked Appt Rate	Un-Booked Appts / Available Appts	MRI Productivity Report	N/A Calculated from previous data	Contractor	Daily, consolidated monthly	Month & Yr	Waste
No-Show Rate	No-Show Appts / Booked Appts	MRI Productivity Report	N/A Calculated from previous data	Contractor	Daily, consolidated monthly	Month & Yr	Waste
Defect	An available MRI appointment that does not result in a completed MRI Exam.	MRI Productivity Report	N/A Calculated from previous data	LSS Belt	Monthly	Month & Yr	Waste
DPMO	Total Defects per 1,000,000 available appointments	MRI Productivity Report	N/A Calculated from previous data	LSS Belt	Monthly	Month & Yr	Waste
Sigma Quality Level	Measure of process performance (defect rate)	NA Calculated	N/A Calculated from previous data	LSS Belt	Monthly	Month & Yr	Waste
PCT	The MRI appt length.	CHCS	Review MRI appt lengths	Radiology Admin	Monthly	Month & Yr	Efficiency
Network MRIs	MRIs completed in the catchment area	M2	M2 Data Pull	Rosa Wages	Qtrly	Month & Yr	Generation 2 of the Project
Cost of Network MRIs	Total Cost Pd by DoD for MRI & Read of MRI	M2	M2 Data Pull	Rosa Wages	Qtrly	Month & Yr	Cost Comparison
Cost / Network MRI	Cost / Network MRI	NA Calculated	Calculated from M2 Data	Rosa Wages	Qtrly	Month & Yr	Cost Comparison
Total MRIs	Network + RACH MRIs	NA Calculated	Calculated from M2 & Contractor Monthly Report	Rosa Wages	Qtrly	Month & Yr	Generation 2 of the Project

Appendix 2

MRI Protocols – Sep 07

BRAIN ROUTINE: Sag T1, Ax T2, Ax PD, Ax Flair, Cor T2, Ax Diffusion, Ax GRE (if trauma)

MRA CAROTIDS: Ax Slinky

MRA CIRCLE OF WILLIS: Sag T1, Ax Sinky

ABDOMEN ROUTINE: Cor T2, Cor T1COR FSEIR, Cor T1 Breath-hold
Cor T2 Breath-hold, Ax T2, Ax T1, Ax Stir PSAT, Ax T1 Breath-hold,
Ax T2 Breath-hold

ADRENALS: Ax T1 Breath-hold, Ax Out-phase, Ax In-phase, Ax T1 FS Breath-hold, Ax T2 EXPRESS, Ax T2 FS, Cor Out-phase, Cor In-phase

CHEST: Ax T2, Ax T1, Ax T2 FS, Ax T2 Breath-hold, Ax T1 Breath-hold, Cor T1, Cor T2, Cor T2 FS, Cor FSEIR, Cor T2 Breath-hold, Cor T1 Breath-hold

HIPS: Cor T2, Cor T1, Cor FSEIR, Ax T2, Ax T1, Sag T2, Sag T1

KIDNEY: Ax T1 Breath-hold, Ax T2 Breath-hold, Ax T2 FS, Ax T1 FS, Cor T1 Breath-hold, Cor EXPRESS

PELVIS: Cor T1, Cor T2, Cor T2 FS, Cor FSEIR, Ax T1, Ax T2, Ax T2 FS, Sag T2

SCAPULA: Ax T2, Ax T1, Ax T2 FS, Cor T1, Cor T2, Sag T2, Sag T1

SHOULDER: Ax T1, Ax T2, Ax PD FS, Cor PD FS, Cor T2 FS, Sag T2 FS, Sag T1

SHOULDER ARTHROGRAM: Ax T1, Ax PD FS, Cor T1, Cor PD FS, Sag T1 FS, Sag T2, T1 FS (in aber position)

ELBOW: Cor T1, Cor T2 FS, Sag T2 FS, Sag T1, Ax T1, Ax T2 FS

WRIST: Cor T1, Cor T2 FS, Cor 3D VOL, Ax T1, Ax T2 FS, Sag T1

HAND:Cor T1, Cor T2 FS, Cor FSEIR, Ax T1, Ax T2 FS, Sag T2 FS

LONG BONE: Cor T1, Cor T2 FS, Cor FSEIR, Ax T1, Ax T2 FS, Ax FSEIR

LONG BONE (Muscle Tear): Ax T1, Ax T2 FS, Ax FSEIR, Cor T2, Cor T1, Sag T1, Sag T2 FS, Sag FSEIR

KNEE: Ax PD FS, Cor T1, Cor PD FS, Sag PD FS, Sag PD, Sag T2 FS

KNEE ARTHROGRAM: Ax T1 FS, Ax PD FS, Cor T1 FS, Cor PD FS, Sag T1 FS, Sag PD FS

ANKLE: Sag T1, Sag T2 FS, Ax T1, Ax T2 FS, Cor T2 FS, Cor T1

FOOT: Sag T2 FS, Sag T1, Cor T2 FS, Cor T1, Cor PD FS, Ax T2 FS, Ax T1

BRACHIAL PLEXUS: Cor T1, Cor T2, Cor FSEIR, Ax T1, Ax T2, Ax FSEIR, Sag T1, Sag T2, Sag FSEIR

CERVICAL SPINE: Sag T1, Sag T2 FS, Sag FLAIR, Ax T2* VOL, Ax GRE, Ax T2

THORACIC: Sag T2 FS, Sag T1, Sag FSEIR, Ax GRE (ALL DISC LEVELS), ADD T1 & T2 Ax IF ABNORMALITY; Cor T1 IF SCOLI

LUMBAR: Sag T2 FS, Sag T1, Sag FSEIR, Ax T2 (BLOCK), Ax T1 (BLOCK), Ax T2 (DISC CUTS)

S.I. JOINTS: Ax T2 FS, Ax T1, Ax FSEIR, Sag T2, Sag T1, Cor T2, Cor T1

Appendix 3

MRI Protocols - Jan 09 (update for shorter time slots and contrast studies)

ABDOMEN (Adrenal): Cor T1, Cor T2, Ax T1, Ax T2, Ax In Phase, Ax Out of Phase

ABDOMEN (Liver): Cor T1, Cor T2, Ax T2, Ax T1, +Ax T1 immediate, +Ax T1 2 min, +Ax T1 5 min.

PELVIS: Cor T1, Cor T2 FS, Ax T2 FS, Sag T2, Sag T1, +Ax T1, +Sag T1, +Cor T1

BRACHIAL PLEXUS: Cor T1 (angled w/ C2-C6), Cor T1 (angled w/sternum), Ax T2, Sag T1, (Opt) Sag T2, (Opt) Sag Stir, +Sag T1, +Cor T1.

SHOULDER ARTHORGRAM: Ax PD FS, Cor T1, Cor PD FS, Sag T2, Lift arm Sag T1 FS.

SHOULDER: Ax PD FS, Cor T2 FS, Sag T2 FS, Sag T1, Cor T1.

ELBOW: Cor PD FS, Cor FSE T2 FS, Sag FSE PD FS, Ax, FSE PD, Ax FSE T2 FS.

HAND: Cor T1, Cor T2 FS, Ax T1, Ax T2 FS, Sag T2 FS.

KNEE: Ax PD FS, Cor FSE T2 FS, Sag PD FS, Sag FSE T2 FS, Cor T1.

ANKLE: Sag T2 FS, Ax T1, Ax T2 FS, Cor T2 FS, Flex foot, Sag T1, (coalition) Cor FSE T2 and Cor GRE.

FOOT: Ax T1, Sag Stir, Cor PD FS, Ax PD FSE, Ax T2 FSE FS.

HIP: Cor T1, Cor FSE T2 FS, Sag FSE PD FS, Ax T2 FS, *Cor Stir.

BRAIN: T1 Sag, T2, Ax, Flair AX, T2 Cor, Ax Diffusion, *Ax T1 if giving contrast, +Ax T1, +Sag T1. MRA: Sag T1, Angio

C-SPINE: Sag T1, Sag T2, Ax GRE, Ax T1 if giving contrast, +Sag T1, +Ax T1 through affected area.

T-SPINE: Sag T1, Sag T2, *Sag Stir, Ax T2, Ax T1 if giving contrast, +Sag T1, +Ax T1 through affected area.

L-SPINE: Sag T1, Sag T2, *Sag Stir, Ax T2, Ax T1 if giving contrast, +Sag T1, +Ax T1 through affected area.

MASS: Long Axis T1, Long Axis Stir, Ax T1, Ax FSE PD FS, Ax FSE T2 FS, +Ax T1, +Long Axis T1

Appendix 4

Business Case Analysis of Acquiring a Siemens Espree MRI

The purchase of a fixed MRI is a significant capital and operational expense. Now that improvements have been addressed to maximize output and efficiency for the contracted MRI, the new projected costs and workload can be compared with a fixed MRI. The main expenses for a fixed MRI are: acquisition, installation, labor, service contract and supplies. The MRI and accessories would cost $1,641,541; a copy of the quote including the upgrades and accessories in included as Appendix 5. The installation and construction would cost $468,668. That construction cost would include a waiting area and two changing rooms, in addition to all the requirements for the MRI. The MRI has a one-year warranty, so the maintenance contract would start one year after installation is complete, each year after would cost $115,389 for the gold package. The maintenance contract includes a software and hardware upgrade in years three and six. The labor cost is $191,400 a year for three Government Service (GS)-9 MRI technologists. The labor cost is based on a GS-9, step 5, Fort Sill employee's salary + 25% additional cost for benefits. The marginal supply cost is estimated at $12,015 per year.

The projected demand for MRIs assumes no increase in utilization, but it does include an 11% increase in demand over FY08 as a result of the 11% increase in the beneficiary population. In FY08, 5,139 MRIs were completed in the catchment area (1,920 at RACH and 3,219 in the network). An 11% increase equates to a demand for 5,704 MRIs per year (2,131 at RACH and 3,573 in the network). It is assumed that all 2,131 MRIs completed at RACH will remain at RACH and 80% of the 3,573 network MRIs could be recaptured. This equates to 4,990 MRIs completed at RACH (2,131 + 2,859) and 714 purchased in the network. Assuming a waste rate of 15% (4% No-show + 4% Un-booked + 3% Last Minute Cancelation + 3% Equipment

Downtime + 0.5% Claustrophobic + 0.5% Contraindication) it would require 5,870 available appointments a year. Assuming the same hours as the expanded contract, an average appointment of length of 30 minutes and closing the MRI on 10 federal holidays, 10 training holidays, and 10 Saturdays on holiday weekends, the fixed MRI would generate 5,952 available appointments. Note, this is slightly different than the extended hours contract, which is scheduled to remain open on all 52 Saturdays of the year. The extended hours contract is projected to result in 4,928 available appointments at RACH and 4,189 completed MRIs (assuming the same 15% waste rate as the fixed MRI). That leaves 1,515 MRIs to be completed in the network. In conclusion, a fixed MRI would result in 801 fewer network MRIs per year than the extended contract.

The current extended hours contract costs $699,000 per year and expires at the end of FY2010. A fixed MRI would result in a cost avoidance of $699,000 starting in FY11 from not renewing the contract. This is assuming the price of the new contract in FY2011 costs the same as the current extended hours contract and the price does not increase in FY12-14. It is assumed that the first fixed MRI would be conducted on 1 Oct 10, the first day of FY11. In reality some under-lap or over-lap would be expected between the contract MRI and the fixed MRI. The projected timeline for the fixed MRI: 1) Sept 09 - GPRMC & MEDCOM review and approve the proposal . 2) Jan 10 - Contract Awarded . 3) May 10 - Construction begins. 4) Aug 10 - Construction, installation and testing complete. 5) Sept 10 - Staff starts working. 6) Oct 10 – First patient seen.

A fixed MRI would result in a purchased care savings of $348,400 per year starting in FY 11. This savings is the result of completing an additional 801 MRIs per year at RACH compared to the extended contract at an average savings of $435 per MRI. This assumes no increase in

MRI utilization, a recapture rate of 80% and an average MRI cost of $435.

Utilizing the MEDCOM Business Case Analysis Tool, the break even date, return on investment (ROI), and cash flows for five years (FY 10-14) were calculated. It was assumed that the MEDCOM paid $2,116,900, the total cost of the MRI and construction on 1 Jan 2010. The only other cost in FY10 for the fixed MRI would be one month's salary for the three MRI technicians at a cost of $16,000. In FY11, the costs for a fixed MRI include the full annual labor cost and the marginal supply cost of $191,400 and $12,015 respectively. The supply cost is calculated by multiplying $15, the estimated cost per MRI, by the 801 additional MRIs per year completed at RACH with a fixed MRI. FY 11 also includes the cost for the first month of the maintenance contract for $9,600. Since the installation was completed in Aug 2010, the warranty would run out in Aug 2011. That leaves one month of the maintenance contract to be paid in FY 11. FY 11-13 each includes the full annual cost for the MRI technicians, maintenance contract and marginal supply cost, which equals $318,000 per year. The costs and benefits are itemized in the table below.

ANNUAL BENEFITS	FY10	FY11	FY12	FY13	FY14
Facility/MTF Savings/Revenue	$0.0	$0.0	$0.0	$0.0	$0.0
Purchased Care Savings	$0.0	$348.4	$348.4	$348.4	$348.4
Other Non-Specified Savings	$0.0	$0.0	$0.0	$0.0	$0.0
Cost Avoidance	$0.0	$699.0	$699.0	$699.0	$699.0
Total Benefit/Savings	$0.0	$1,047.4	$1,047.4	$1,047.4	$1,047.4
COST					
OPERATING EXPENSE ITEMS					
Personnel - GS & Contract	($16.0)	($191.4)	($191.4)	($191.4)	($191.4)
Non-Capital Lease/Rental/Maintenance	$0.0	($9.6)	($115.4)	($115.4)	($115.4)
Supplies	$0.0	($12.0)	($12.0)	($12.0)	($12.0)
Other	$0.0	$0.0	$0.0	$0.0	$0.0
CAPITAL ASSETS PURCHASED					
Equipment (Lease & Purchase)	($1,646.9)	$0.0	$0.0	$0.0	$0.0
Facilities	($468.7)	$0.0	$0.0	$0.0	$0.0
Total Cost	($2,131.5)	($213.1)	($318.8)	($318.8)	($318.8)
Net Yearly Cash Flow	($2,131.5)	$834.4	$728.6	$728.6	$728.6
Net Cumulative Cash Flow	($2,131.5)	($1,297.1)	($568.5)	$160.1	$888.7

A Cash Flow Summary is included below:

Total Project - CASH FLOW SUMMARY	Year 1	Year 2	Year 3	Year 4	Year 5
Cash inflows (outflows)	Sep 2010	Sep 2011	Sep 2012	Sep 2013	Sep 2014
Annual benefit impacts	0.0	1,047.4	1,047.4	1,047.4	1,047.4
Annual expense item impacts	(16.0)	(213.1)	(318.8)	(318.8)	(318.8)
Net operating inflow (outflow)	(16.0)	834.4	728.6	728.6	728.6
Asset purchase	(2,115.5)	0.0	0.0	0.0	0.0
Net CASH FLOW	**(2,131.5)**	**834.4**	**728.6**	**728.6**	**728.6**
Cumulative Net Cash Flow	(2,131.5)	(1,297.1)	(568.5)	160.1	888.7
Discounted Cash Flow - NPV at 2.3%	**(2,131.5)**	**815.6**	**696.2**	**680.6**	**665.3**
Cumulative Discounted Case Flow	(2,131.5)	(1,315.9)	(619.7)	60.9	726.1

Over the five year period, the government would spend $3,271,000 on a fixed MRI, but it would save $4,189,700 compared to the extended MRI contract. A summary of the Financial Benefits and ROI is included below:

Tangible/Financial Benefits: (Complete Analysis Period: 5 Years)			
Investment:	**($3,301.1)**	**Savings:**	**$4,189.7**
Net Savings:	**$888.7**	**Simple ROI:**	**26.9%**

The project would break even on 11 November 2012, 2.9 years after the MRI was purchased and 2.1 years after the first patient was seen. The assumptions utilized in this BCA were intended to be conservative and allow a fair buy versus lease comparison. The most likely deviation from the assumptions would be an increase in MRI utilization, especially for breast imaging. Any increase in MRI utilization favors buying a fixed MRI over a lease because the marginal cost is minimal to increase workload for the fixed MRI. The project included three MRI techs which allows RACH to expand the hours without having to hire additional staff. Finally, no revenue from Third Party Collections (TPC) or "selling" MRIs to the Veteran's Administration (VA) were included. In addition to the $1.4 million the government paid for

network MRIs in FY 08, another $120,000 was paid by Other Health Insurance (OHI) which reduced the cost to the government. RACH may not be as successful at TPC as the network is at collecting from OHI, but it illustrates that additional workload at RACH could result in some TPC. There is a VA clinic adjacent to RACH that purchases radiology and laboratory services at 90% of the Champus Maximum Allowable Charge (CMAC). Currently, the VA clinic either purchases MRIs in the local network or transports their patients to the VA hospital in Oklahoma City to get their MRIs. The VA leadership has expressed an interest in "purchasing" MRIs from RACH. A summary of the assumptions are listed below:

Assumptions

1. No increase in MRI utilization per 1000 beneficiaries / year.
2. Population increases 11% from FY2008, resulting in demand for 11% more MRIs
3. Appointments average 30 minutes for fixed MRI
4. Maximum 80% recapture rate for network, ambulatory, non-emergent MRIs for under 65 yrs old
5. No increase in costs: labor, supplies, contracts, etc.
6. 15% Waste d appointments = 4% No-show rate + 3% MRI downtime +4% Un-booked Appointments + 0.5% Contraindications + 0.5% Claustrophobic + 3% Last minute cancelation
7. Contracted MRI trailer is closed for 10 federal holidays & 10 training holidays
8. Fixed MRI is closed for 10 federal holidays, 10 training holidays and 10 Saturdays on holiday weekends.
9. Supply costs = $15/MRI
10. No MRI appointments "sold" to the VA
11. No Third Party Collections
12. 2.3% Discounted cash flow rate, set by the Office of Management and Budget

Appendix 5

MAGNETOM Espree Quote as Configured for RACH

All items listed below are included for this system:

I-class #Tim

I-class is the new generation of Tim-based MRI scanners, which enables innovative applications and workflow efficiency. The I-class package comprises: - 3D Distortion Correction - MPPS - ImageFilter SW - PhoenixZIP - DICOM Study Split

Tim [76x18] Z-engine #Es

Tim [76x18] Z-engine performance level Tim [76x18] is Total imaging matrix with 76 seamlessly integrated coil elements, combinable to 18 RF channels. It is for demanding high-end applications and optimized throughput. Tim [76x18] has flexibility in Parallel Imaging. PAT factors up to 4 (one direction) or 12 (in two directions, optional) help speed acquisitions. Maximum SNR is ensured through the new matrix coil technology. Z-engine Gradient System The Z-engine is designed combining high performance while minimizing acoustic noise.

Label Tim [76x18] #Es

Label on the front cover displaying the Tim level of the system.

PC Keyboard US english #Av

Standard PC keyboard with 101 keys.

Cover Satin White #Es

The color of the main face plate cover with integrated control panel and table display is Translucent Teal. The table elevator cover and adjoining upper left cover are presented in an optically appealing Satin White design.

Remov. Matrix Table w.Trolley #Es

The patient table is mounted directly to the magnet assembly. The table can support up to 200 kg (440 lbs) patients with unrestricted vertical and horizontal movement. The removable table allows docking of the table top with a trolley for preparing patients outside the scan room for maximum flexibility and speed.

4-channel Flex Coil Pckg #Tim (1.5 sys)

The 4-channel Flex Coil Kit offers a set of flexible coils with the capability for parallel imaging for easy and quick examinations of a large variety of different anatomies. The following items are included: - 4-channel Flex coil, large - Wrap-around coil made of soft and flexible material - Capable of parallel imaging with iPAT factors up to 2 ($iPAT^2$ up to 4) - For applications such as imaging of large regions, e.g. medium to large shoulders, hip and knee - 4-channel Flex coil, small - Wrap-around coil made of soft and flexible material - Capable of parallel imaging with iPAT factors up to 2 ($iPAT^2$ up to 4) - For applications such as imaging of small regions, e.g. small to medium shoulders, wrist, elbow and ankle - 4-channel Flex Coil Interface - For connection of e.g. the large or small 4-channel Flex coil

PMU Bluetooth Physio Control #Av

Physiological Measurement Unit (PMU) - Wireless Physio Control for wireless triggering, synchronizes the measurement with the physiological cycles of cardiac and/or respiratory motion. Wireless technology for all sensors allows fast and easy patient set-up and comfort, and robust cardiac or respiratory signal transmission as it eliminates the need to attach cables to the patient. The Wireless Physio Control contains wireless VCG, respiration and pulse sensors and a charging station as all sensors are powered by rechargeable batteries.

Native syngo #Tim

This package contains sequences and protocols for non-contrast 3D MR angiographic imaging with high spatial resolution. NATIVE allows imaging especially of abdominal and peripheral vessels and is an alternative to MR angiography techniques with contrast medium, especially for patients with severe renal insufficiency.

BLADE #Tim

Motion and flow insensitive multi-shot Turbo Spin Echo (TSE) sequence for all body regions with optional inter-shot motion correction.

Composing syngo #Tim

This application provides dedicated evaluation software for creating full-format images from overlapping MR volume data sets and MIPs (starting from syngo MR B13) acquired at multiple stages.

Inline Composing syngo #Tim

This Inline Package includes a dedicated software for the generation of full-format images from overlapping MR volume data sets and MIPs from several steps - fully automatic, directly after measurement.

Inline Diffusion #Av

Automatic real-time calculation of trace-weighted images and ADC maps with Inline technology. Compatible to single-shot diffusion-weighted EPI.

Body Matrix Coil #Av

The new multi-element Matrix coil technology is an essential part supplementing the most innovative Total imaging matrix. Matrix coils have multiple receive coil elements that can be clustered in groups. Each receive coil element is equipped with a low noise preamplifier to maximize signal-to-noise ratio. The Body Matrix Coil features: - 6-element design with 6 integrated preamplifiers, with 2 clusters of 3 elements each - Operated depending on the Matrix Coil Mode as a 2-channel coil (CP Mode), 4-channel coil (Dual Mode) or 6-channel coil (Triple Mode) - Operates in an integrated fashion with the Spine Matrix coil (2 rings of 6 elements each = 12-element design) - Can be combined with further Body Matrix coils for larger coverage - No coil tuning - iPAT-compatible Applications: - Thorax (incl. heart) - Abdomen - Pelvis - Hip Can be combined with: - Head Matrix coil - Neck Matrix coil - Spine Matrix coil - Additional Body Matrix coils (typically 2-3 in total) for additional anatomical coverage - PA Matrix coil (Peripheral Angio Matrix; optional) - All flexible coils (e.g. CP Flex coil, small, CP Flex coil, large) - CP Head Array coil - Endorectal coils

Shoulder Array Coil #Es
This iPAT compatible coil for examinations of the left or right shoulder consists of a base plate and two receive array coil attachments available in different sizes, these will be attached and can be relocated on the basis plate.

8-channel Knee Coil #Av,Es

8-channel Foot/ Ankle Coil #Es
The 8-channel foot-ankle coil is an iPAT-compatible "no-tune" receiver coil for the examination of the foot and the ankle joint.

MR Workplace Table 1.2m
Table suited for syngo Acquisition Workplace and syngo MR Workplace based on syngo Hardware.

MR Workplace Container, 50cm
50 cm wide extra case for the syngo host computer with sliding front door to allow change of storage media (CD/DVD/USB).

Cable Set syngo 8/12 #Es
Cable length inside the cabin 8 m, cable length outside the cabin 12 m. Inclusive Ethernet Twisted Pair Adapter and 10 m cable.

Venting Kit #Av,Es
Overpressure valve as a transport safety device for cold delivery of the magnet by air and sea freight. Designed for: - atmospheric pressure conditions at sea level during land and sea transport, as well as - low pressure during air transport.

Helium Fill 30/60 H,S,SON

Chiller, 60 Hz #Av

UPS Cable #Tim
Power cable for the UPS-system UPS Powerware PW 9125-3000i (8857810) at the ACC of the MAGNETOM Tim systems for backing up the computer. Standard cable length 9 m.

UPS Powerware PW9130G-3000T-XLEU
UPS system Eaton PW9130-3000G-3000T-XLEU for MAGNETOM Tim and MAGNETOM Symphony systems for safeguarding computers. Power output: 3.0 kVA / 2.7 kW Bridge time: 5 min full load / 14 min half load Input voltage: 230 VAC

Standard Cryogens

Armrest #MR

MR Project Management

Initial onsite training 32 hrs

Follow-up training 24 hrs

GOV'T ONLY - MR Training Class

Chiller Start-up and Warranty for TIM

One complimentary biomedical tuition is included with the purchase of this system to be completed during the warranty period.

2nd set of operator and service manuals

7/16 Invivo Coil, as per proposal 2300034425 @ $113,850

MR_GOV_RIG_INSTL

EmpowerMR Injector System

8-channel Wrist Coil Tim

The 8-channel wrist coil is an iPAT-compatible "no-tune" receiver coil for the examination of the wrist.

System Total: $1,641,541

Appendix 6

Final Results After the Purchase and Installation of the New MRI and High-Efficiency Process

Between May 2009 and April 2011, the LSS project increased MRI production from 167 MRIs per month to 325, resulting in a net savings of ~$1 Million. The BCA was approved and the installation of the fixed MRI was completed in April 2011. The new MRI specifications and layout of the check-in desk, waiting area, changing rooms, and MRI technologist work area were all designed to optimize the productivity of the new system by minimizing steps for staff and patients and providing sight lines to minimize staffing requirements. From April – September 2011, RACH completed ~500 MRIs per month, three times the baseline. The annual savings for the government is ~$1 Million per year and $7-10 million over the life of the MRI machine.