Clinical Engineering Benchmarking

Alan Gresch, VP of HTM Consulting

Phoenix Data Systems

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Past Benchmarking Efforts in US

- ECRI Biomedical Benchmarking
  - Average annual PM hours by Device Type
  - Average annual CM hours by Device Type
  - Average PM Intervals by Device Type
- AAMI Benchmarking
- Truven (Health Analytic's Action I-O Operational Performance Improvement Solution)

AAMI Sponsored CMMS Collaborative

Company	CMMS
Accruent	Connectiv, TMS, EAM
EQ2	HEMS
MediMizer	MediMizer
Nuvolo	Nuvolo
Phoenix Data Systems	AIMS
TMA Systems	WebTMA

Failure Codes

Option	Definition	Examples
Accessory or Disposable Failure ✓	Failure of device accessory or disposable, not a failure of the device itself.	ESU footswitch. Infusion pump cassette.
Calibration Failure ✓	Failure of a device to meet calibration parameters, requiring recalibration.	Need to adjust low-battery alarm trigger point.
Component Failure (Battery) ✓	Failure of the battery that provides power for device operation.	Battery fails to hold a charge. Battery reconditioning fails.
Component Failure (Not Battery) ✓	Failure of a device component other than the battery.	Infusion pump pressure sensor. Device power cord. Device display.
Failure Caused by Maintenance ✓	Failure of a device resulting from maintenance activities.	Physical damage during maintenance. Overvoltage during testing.
Failure Caused by Abuse or Negligence	Failure of a device resulting from damage caused by intentional misuse or negligent use.	User drops defibrillator. Patient damages infusion pump.
Network or Connectivity Failure	Functional failure external to device from failure of network or connectivity.	Network connection not accessible. Infusion pump library not updated.
Software Failure	Functional failure of a device resulting from malfunctioning software.	Infusion pump software malfunctions. Physiological monitor required rebooting.

Failure Codes

Option	Definition	Examples
Use Error (Use Failure)	Failure of a device to support achievement of a clinical objective.	User error. Infusion pump programming error.
Failure Caused by Utility System	Functional failure of a device resulting from failure of or access to a utility system.	Electrical power. Medical gas or vacuum. Ventilation.
Failure Cause by Environmental Factor	Functional failure of a device resulting from an environmental factor.	Excessive ambient temperature. Excessive relative humidity.
Failure Could Not Be Identified	Reported failure could not be reproduced or identified by testing.	Inaccurate or incomplete report of failure. Intermittent device failure.
Failure Not Diagnosed—Device Not Repaired	Reported failure indicated that testing or repair was unwarranted.	Device replacement was more cost-effective than testing or repair.
No Failure Associated with the WO	There was no failure associated with the work order (included for completeness).	PM work order completed normally. PM work order could not be completed.

✓ = PM-related failure

WO = work order

Work Order Types

Name	Code	Aliases/Synonyms	Description
Planned Maintenance ✓	PM	• Scheduled maintenance • Preventive maintenance • Preventative maintenance	Used for a single CMMS asset, not multiple assets. Costs associated with these activities are allocated to a particular asset. Activities (what we do) include: • Device restoration • Safety & function testing/inspection Not used for: • Corrective maintenance discovered during PM • Incoming inspection • Safety & function testing after repairs or other unscheduled activities
Corrective Maintenance ✓	CM	• Repair • Unscheduled maintenance	Used for a single CMMS asset, not multiple assets. Costs associated with these activities are allocated to a particular asset. Circumstances for use: • Found during PM • Reported by equipment users (even if no deficiency is actually found) • Identified by HTM personnel (even if no deficiency is actually found) Activities (what we do) include safety & function testing to: • Identify and correct deficiencies • Confirm that equipment is safe & effective following CM Not used for: • Incoming inspection • Installation • Deinstallation, decommissioning, disposal • Recall & alert management • Software update/upgrade • Cybersecurity remediation

Work Order Types

Name	Code	Aliases/Synonyms	Description
Training—HTM Staff	TRAINING		Used to document HTM personnel technical training and professional development. Costs associated with these activities are not allocated to a particular asset. Activities (what we do) include: • OEM/3rd-party technical training • Peer-to-peer technical training • Mentoring
Support—Users	SUPPORT		Used to provide non-maintenance support to users. Costs associated with these activities may or may not allocated to a particular asset. Activities (what we do) include: • Rounds—informal check-in with users • Training on specific medical devices/system
Project	PROJECT		An activity with a defined START and COMPLETION point (date) that is not PM or CM. Has a specific objective that is formally managed in terms of content, timeline, and deliverables. Costs associated with these activities may or may not be allocated to a particular asset. Activities may include meetings as well as technical work. • Installation • Deinstallation, decommissioning, disposal • Software update/upgrade • Construction/renovation • Medical device integration/interoperability
Administrative	ADMIN		Ongoing activities with no definitive START and COMPLETION point (date). Costs associated with these activities are not allocated to a particular asset. • Meetings (e.g., HTM department) • Capital equipment planning • Cleaning the workspace (HTM shop)

Work Order Types

Name	Code	Aliases/Synonyms	Description
Cybersecurity ✓	CYBER		An activity specific to: • Mitigation • Breach response • Remediation
Recall & Alert Management ✓	RECALL		Initiated by the FDA and/or the OEM.
Incident Investigation[1]	ADVERSE EVENT		An event resulting in, or the potential for, harm or death of a patient, staff, visitor.
Incoming Inspection ✓	INCOMING		Activity required to complete a performance verification and add (enter) equipment asset into MEMP and CMMS; any device not already in the CMMS inventory: • NEW • Patient owned • Reactivated • Demonstration, loaned, rented

✓ = Maintenance-related *Work Order Type*

MEMP = Medical equipment management plan

OEM = Original equipment manufacturer

[1] IT Services uses the term "incident" to describe any failure whereas HTM uses the term to refer to situations when there is patient/staff harm or the potential for harm.

Request/Work Order Codes (with clear definitions)

RequestCode	RequestDescription	RequestDefinition/Notes
1	Planned Maintenance	Used for all scheduling purposes to track scheduled maintenance
2	Safety Test	First tier in for scheduling purposes to signify electrical safety was performed on the device
4	Incoming Inspection	Used for checking in, installing/delivering of new equipment
3	Corrective Maintenance	Unplanned work order events where there is some type of equipment failure (either real or user stated)
5	Service Request	Automated requests - must be changed to appropriate request by technician to close work order
6	Education	Used to document any training received or given (hospital policies, infection control, equipment maintenance, In-Service)
7	Hazard Alert/Recall	Used to document work done when a hazard alert or a recall has been issued on an inventoried device or a non-inventoried system. Completing this work order indicates both the action and documentation required by the recall have been completed.
8	Incident Investigation	Used to record work investigating a patient incident. Outputs, control settings, and all critical information will be logged in the time task text. See Lead before beginning any repairs or modifications. No patient ID in WO.
9	Project	Used to document work done for an assignment that involves planning, design, and implementation. Projects typically extend beyond 3 hours. A lead or supervisor must initiate all projects and a project template is required.
10	Rounds	Used to document time doing rounds on floors
11	Administrative	Used to document activities that are defined productive time, but do not fall under other request categories (paperwork, cleaning bench, non-project meetings, etc)
12	Physicist Correction	Physicist work order tracking for identified problems with equipment they perform regular checks on

Associated Result Codes (with clear definitions)

Request	Result	RequestResultDefinition/Notes
Administrative	Cleaning	Any time needed to clean your own workspace or shared/storage space
Administrative	Inventory	Time tracked for performing inventory on parts, equipment, etc
Administrative	Meeting	Attended meeting that was not project based or considered education (weekly department meetings, safety huddles, etc)
Administrative	Other	Other administrative task besides those defined
Administrative	Paperwork	Various tasks involving updating manual libraries, doing backlogs of work orders, etc
Corrective Maintenance	Major Failure	Failure could have affected patient safety and/or device would not work without repair
Corrective Maintenance	Minor Failure	Small Repair including Calibration – Cosmetic, Screen fix,Cord Replaced, did not affect safety or function of the device
Corrective Maintenance	No Problem Found	No additional action required outside of normal testing procedures
Corrective Maintenance	Removed from Service	No longer needed on the floor or obsolete/will not be fixed
Education	Received Training	Hospital Education or another staff member trained you on a topic/piece of equipment
Education	Trained Biomed	Trained staff member in CE department on a topic/piece of equipment
Education	Trained Clinical	Performed an in-service to clinical staff for new pieces of equipment, as requested by staff, or recommended due to high operator error
Hazard Alert/Recall	Completed	Service necessary to resolve Alert/Recall has been performed (replacing part, changing a setting, installing new part, etc) – place specific details in notes section
Incident Investigation	Major Failure	Failure could have affected patient safety and/or device would not work without repair
Incident Investigation	Minor Failure	Small Repair including Calibration – Cosmetic, Screen fix,Cord Replaced, did not affect safety or function of the device
Incident Investigation	No Problem Found	No additional action required outside of normal testing procedures
Incident Investigation	Removed from Service	No longer needed on the floor or obsolete/wiil not be fixed
Incoming Inspection	Major Failure	Failure could have affected patient safety and/or device would not work without repair
Incoming Inspection	Minor Failure	Small Repair including Calibration – Cosmetic, Screen fix,Cord Replaced, did not affect safety or function of the device
Incoming Inspection	No Problem Found	No additional action required outside of normal testing procedures
Physicist Correction	Completed	Physicist Correction information was entered
Planned Maintenance	Major Failure	Failure could have affected patient safety and/or device would not work without repair
Planned Maintenance	Minor Failure	Small Repair including Calibration – Cosmetic, Screen fix,Cord Replaced, did not affect safety or function of the device
Planned Maintenance	No Problem Found	No additional action required outside of normal testing procedures
Planned Maintenance	Removed from Service	No longer needed on the floor or obsolete/wiil not be fixed
Planned Maintenance	Unable to Locate	Device was not found after 3+ attempts to locate device during PM cycle with time captured for attempts (per department policy, may vary)
Project	Completed	Project tasks were completed, details in time task notes
Rounds	Completed	Rounds were completed, details in time task notes
Safety Test	Major Failure	Failure could have affected patient safety and/or device would not work without repair
Safety Test	Minor Failure	Small Repair including Calibration – Cosmetic, Screen fix,Cord Replaced, did not affect safety or function of the device
Safety Test	No Problem Found	No additional action required outside of normal testing procedures
Safety Test	Removed from Service	No longer needed on the floor or obsolete/wiil not be fixed

Associated Fault Codes (with clear definitions)

Request	Fault	RequestFaultDefinition/Notes
Corrective Maintenance	Could Not Replicate	No additional action required outside of normal testing procedures, could not replicate original failure/complaint
Corrective Maintenance	Incorrect Set-Up	The equipment was setup incorrectly prior to use that caused an error in device use (ex. Anesthesia/vent circuits)
Corrective Maintenance	Maintenance Preventable	Any problems found that would normally be addressed during scheduled/preventative maintenance (ex. Changing batteries, battery contacts, filters, lubricating O-rings etc)
Corrective Maintenance	Network/Software Failure	Failure due to IT network, transmission issues, or any software related problems
Corrective Maintenance	Operator Error	Operator was uncertain of how device operates
Corrective Maintenance	Physical Abuse	Clear evidence of damage outside of normal use
Corrective Maintenance	Removed from Service	No longer needed on the floor or obsolete/wiil not be fixed
Corrective Maintenance	Spontaneous Failure	No amount of testing could have predicted the failure **within** the device
Corrective Maintenance	Utility Failure	Environmental factors such as electricity, water, temperature caused the device to work improperly
Incident Investigation	Could Not Replicate	No additional action required outside of normal testing procedures, could not replicate original failure complaint
Incident Investigation	Incorrect Set-Up	The equipment was setup incorrectly prior to use that caused an error in device use (ex. Anesthesia/vent circuits)
Incident Investigation	Maintenance Preventable	Any problems found that would normally be addressed during scheduled/preventative maintenance (ex. Changing batteries, battery contacts, filters, lubricating O-rings etc)
Incident Investigation	Network/Software Failure	Failure due to IT network, transmission issues, or any software related problems
Incident Investigation	Operator Error	Operator was uncertain of how device operates
Incident Investigation	Physical Abuse	Clear evidence of damage outside of normal use
Incident Investigation	Removed from Service	No longer needed on the floor or obsolete/wiil not be fixed
Incident Investigation	Spontaneous Failure	No amount of testing could have predicted the failure within the device
Incident Investigation	Utility Failure	Environmental factors such as electricity, water, temperature
Incoming Inspection	No Problem Found	No additional action required outside of normal testing procedures, used for No Problem Found Result
Incoming Inspection	Spontaneous Failure	No amount of testing could have predicted the failure within the device
Planned Maintenance	Maintenance Preventable	Any problems found that would normally be addressed during scheduled/preventative maintenance (ex. Changing batteries, battery contacts, filters, lubricating O-rings etc)
Planned Maintenance	No Problem Found	No additional action required outside of normal testing procedures, used for No Problem Found Result
Planned Maintenance	Removed from Service	No longer needed on the floor or obsolete/wiil not be fixed
Planned Maintenance	Spontaneous Failure	No amount of testing could have predicted the failure within the device
Safety Test	Maintenance Preventable	Any problems found that would normally be addressed during scheduled/preventative maintenance (ex. Changing batteries, battery contacts, filters, lubricating O-rings etc)
Safety Test	No Problem Found	No additional action required outside of normal testing procedures, used for No Problem Found Result
Safety Test	Removed from Service	No longer needed on the floor or obsolete/wiil not be fixed
Safety Test	Spontaneous Failure	No amount of testing could have predicted the failure within the device

Manning Data

Device Category	Active Inventory	Rich's Hours per device	Rich's Total Device Hours
Aerator, Ethylene Oxide	6	1.90	11.40
Air Cleaner, Particulate, Germicidal, UV	3	1.00	3.00
Air Cleaner, Particulate, High-Efficiency Filter	4	0.00	0.00
Alarm, Occupancy, Bed	928	0.75	696.00
Amalgamator	5	1.00	5.00
Analyzer, Lab, Hematology, Platelet Aggregation	4	0.30	1.20
Analyzer, Lab, Hemo,Erythrocyte Sedimentation Rate	96	0.30	28.80
Analyzer, Lab, Immunoassay, Chemiluminescent	2	0.80	1.60
Analyzer, Lab, Immunoassay, Photometric, Microplat	14	0.74	10.36
Analyzer, Lab, Microbiology, Susceptibility, Auto	28	0.74	20.72
Analyzer, Laboratory, Blood Gas/pH	22	0.76	16.72
Analyzer, Laboratory, Body Fluids, Glucose	3	0.51	1.53
Analyzer, Laboratory, Breath, Carbon Dioxide	3	0.51	1.53
Analyzer, Laboratory, Clinical Chemistry	61	0.28	17.08
Analyzer, Laboratory, Hematology	77	0.42	32.34
Analyzer, Laboratory, Hematology, Coagulation	57	0.56	31.92
Analyzer, Laboratory, Hematology, Hemoglobin	7	0.56	3.92
Analyzer, Laboratory, Immunoassay	40	1.30	52.00
Analyzer, Laboratory, Urine	109	1.03	112.27
Analyzer, Phys, Middle Ear, Impedance Tympanometry	116	0.80	92.80
Analyzer, Phys, Neuro Musc Funct, Body Motion	20	4.81	96.20
Analyzer, Phys, Neuromuscular Funct,Posturographic	3	2.65	7.95
Analyzer, Phys, Peristaltic Motility, Esophageal	7	0.75	5.25
Analyzer, Physiologic, Body Composition	4	1.00	4.00
Analyzer, Physiologic, Joint Laxity	1	1.00	1.00
Analyzer, Physiologic, Metabolic Rate, O2 Based	1	2.77	2.77
Analyzer, Physiologic, Pulmonary Function	27	4.78	129.06

Annual Manning Analysis

Modality	Metro Net Adds	Metro hrs/year	Central Net Adds	Central hrs/year	KM Net Adds	KM hrs/year	North Net Adds	North hrs/year	South Net Adds	South hrs/year	System Total hrs/year	FTE's
General Biomedical Totals	903	1447.30	736	971.80	-161	-10.28	802	990.32	474	464.78	3863.92	3.14
Biomedical Specialty Totals	54	92.10	18	104.93	8	50.95	15	77.02	19	66.17	391.17	0.32
Imaging Group I Totals	78	241.80	35	468.99	12	50.71	26	371.44	37	453.28	1586.22	1.29
Imaging Group II Totals	67	302.58	49	209.33	20	17.00	51	95.43	44	83.36	707.70	0.58
TOTALS	1102	2083.78	838	1755.05	-121	108.38	894	1534.21	574	1067.59	6549.01	5.32

Modality	Total Hours Added	Available Device Hours per FTE	Total FTE's
General Biomed	3863.92	1230.25	3.14
Biomed Specialty	391.17	1230.25	0.32
Imaging I	1586.22	1230.25	1.29
Imaging II	707.70	1230.25	0.58
FTEs All Modalities	6549.01	1230.25	**5.32**

Inventory Growth	
Aurora Total Inventory 8/22/2006	45,501
Net Adds 08/23/2006 to 8/07/2007	3,287
Aurora Total Inventory 8/7/2007	48,788
Percentage Inventory Growth	**7.22%**

Productivity = 100.8%
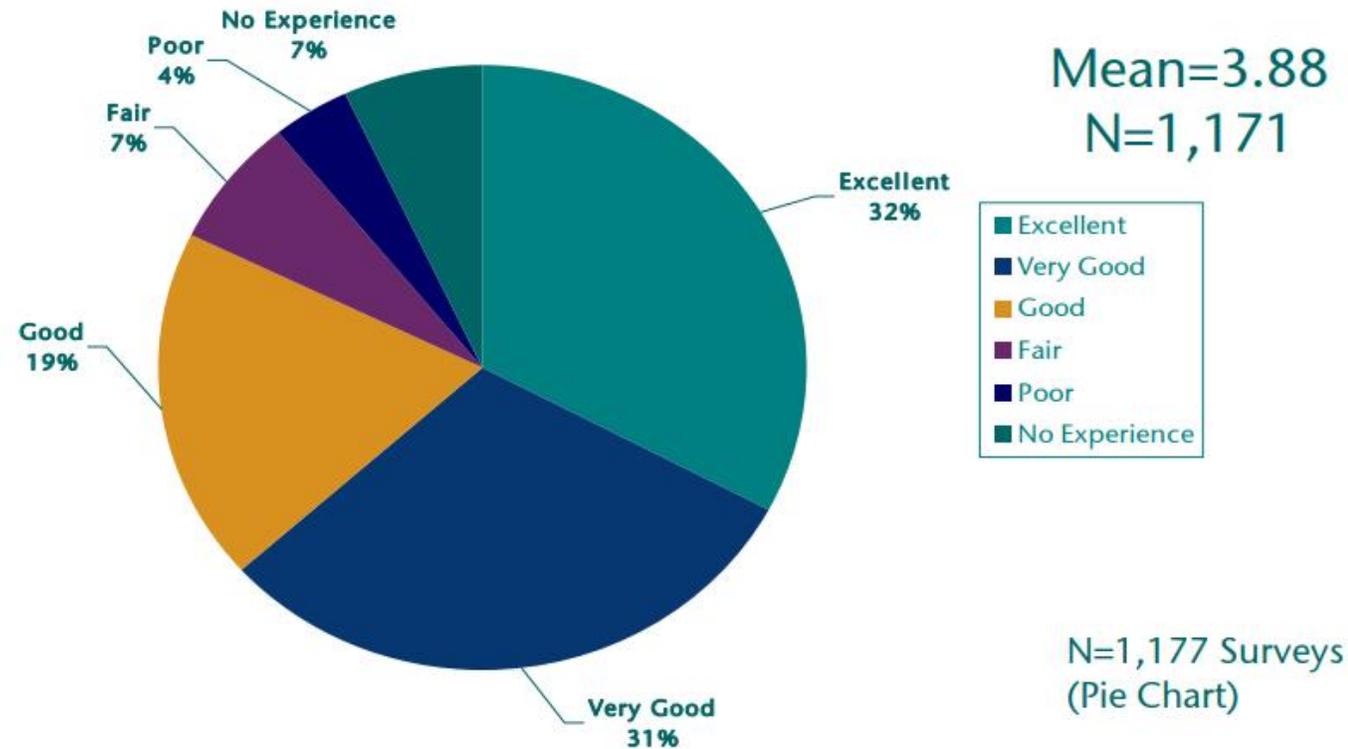
Conclusions/Recommendations

- Standardize Codes and Define Them Clearly
- Train Staff
- Enforce Documentation Standards and Data Integrity
- Benchmark Internally First
  - Average PM/CM Hours by Device Type
- Implement CoSR (Cost of Service Ratio) Measures
- Implement Customer Satisfaction Measures
- Choose a Measurement Methodology and Stick With It
- Focus on Getting Better Year Over Year

Clinical Engineering Client Satisfaction Survey Quality of Communication

Q6. Please rate the quality of communication regarding equipment status from Clinical Engineering.

Mean=3.88
N=1,171

Legend:
- Excellent
- Very Good
- Good
- Fair
- Poor
- No Experience

Pie chart values:
- Excellent 32%
- Very Good 31%
- Good 19%
- Fair 7%
- Poor 4%
- No Experience 7%

N=1,177 Surveys
(Pie Chart)

Clinical Engineering Client Satisfaction Survey
Quality of Communication
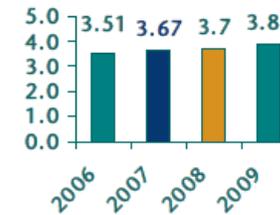
Q6. Please rate the quality of communication regarding equipment status from Clinical Engineering.
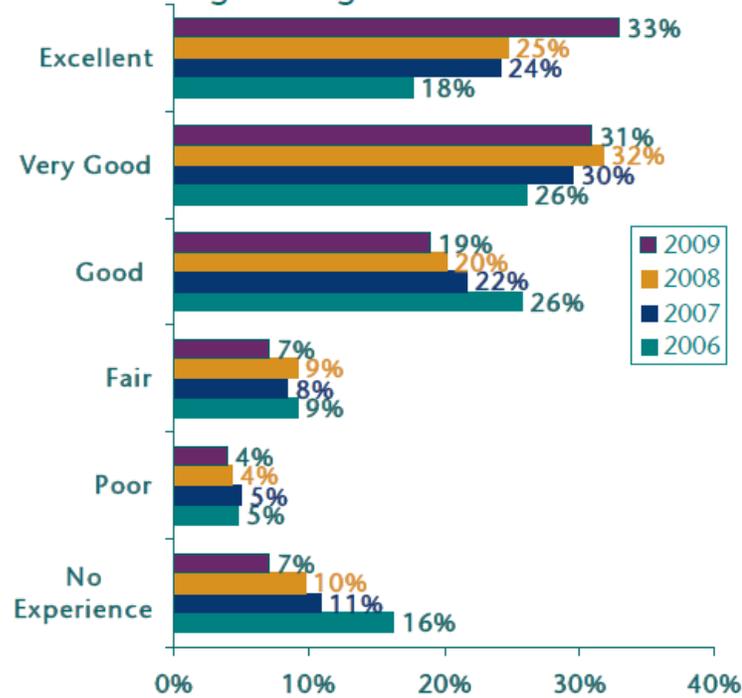
	2006	2007	2008	2009
Mean	3.51	3.67	3.70	3.88
N	1,820	1,288	1,143	1,171

Total Surveys

N=2,174 (2006)

N=1,446 (2007)

N=1,266 (2008)

N=1,177 (2009)

	Benchmark	Goal	Jan	Feb	Mar	Year End Totals/Averages	Variance from target
AIR PROGRAM							
Transfers			$15,330	$6,355	$33,432	$416,930	N/A
Sales			$23,129	$17,170	$12,628	$250,263	N/A
Net Expense Ratio			3.11/1	1.70/1	2.66/1	3.73/1	0.73
CLINICAL ENGINEERING							
Cost Savings			$76,049	$58,774	$112,157	$1,072,660	N/A
Cost Avoidance			$165,000	$164,572	$158,305	$1,771,960	N/A
Cost of Service Ratio			1.32%	4.45%	3.96%	4.02%	N/A
Number of Devices per Technician							
General Biomed	1,580		1,495	1,495	1,458	1418.50	-161.50
Specialty Biomed	267		269	275	303	283.92	16.92
Imaging I	168		164	165	165	159.67	-8.33
Imaging II	226		235	239	242	240.08	14.08
Downtime Hours Major Modalities							
Lin Acc	46.6		39.1	17.8	3.8	22.56	-24.05
CT	60.1		96.3	24.5	6.3	62.47	2.33
CT/PET	1.0		17.8	3.0	22.1	5.74	4.79
MR	26.3		31.0	14.0	8.2	17.61	-8.68

	Benchmark	Goal	Jan	Feb	Mar	Year End Totals/Averages	Variance from target
CLINICAL ENGINEERING							
Repair Hours							
Corrective	5952.6		5526.8	4984.3	4828.5	4388.92	-1563.64
Planned	2866.8		3021.8	2873.1	3393.2	3001.85	135.09
Total Requests for Service							
Corrective	1,932		1,996	1,762	2,206	1831.08	-100.67
Planned	20		14	19	17	12.92	-7.00
Service Completed In-house							
Corrective	96.00%		97.20%	96.40%	95.50%	95.10%	-0.90%
Planned	99.90%		100.00%	100.00%	100.00%	99.96%	0.06%
Service Called in After Hours							
Corrective	0.22%		0.20%	0.40%	0.14%	0.26%	0.04%
Planned	0.00%		0.00%	0.00%	0.00%	0.00%	0.00%
Productivity	101.80%		103.90%	102.10%	103.00%	102.75%	0.95%
Response Time (minutes)							
In-house	16		15	18	16	17.92	1.92
Vendor	52		47	52	36	50.92	-1.08
Customer Satisfaction (1-5 scale)	4.09		4.09			4.15	0.06

Thank you!

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