Implementing a Computerized Maintenance Management System for a Consolidated Program

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This article reframes the typical computerized maintenance management system (CMMS) discussion from *what* is required to *how* to implement a CMMS. It discusses governance structure, vision, a few data integrity features, cultural shift, and future use. The article considers the practical challenges associated with combining operations and data processes to result in a successful project. The implementation of a CMMS for a large consolidated program is no small feat and should be approached with much enthusiasm, broad discussion, plenty of consideration, reasonable flexibility, and some wishful thinking. It is our hope that this article could serve as a template or at least an ideas springboard for other clinical engineering departments undergoing expansion.

The computerized maintenance management system (CMMS) database was described in the *Journal of Clinical Engineering* as early as 1985 by Kresch et al.[1] At the core of every clinical engineering (CE) department is a documentation system, whether paper, computerized, or cloud based. The vast majority of CMMS literature describes the fundamental requirements and functionality of the CMMS system as a repository for assets, work orders (WO), internal and external service records, preventive maintenance (PM) schedules, warranty periods, parts inventory, service contract and purchasing information, quality assurance, reporting, cost control, and alerts and hazards.[1-9] Thirty years later, these aspects of a CMMS have been well elucidated and for the most part have not changed. What has changed is the structure of CE departments and how the data are captured in the CMMS.

We expect that many other CE departments have undergone transition of their departments from site specific toward a regional model. Herein, we describe our experience venturing into a consolidated program using the CMMS as the focal point for conversations about governance, business processes, operational requirements, technology management, and ongoing support of clinical services.

This article reframes the typical CMMS discussion from *what* is required to *how* to implement a CMMS. It will discuss our governance structure, vision, a few data integrity features, our cultural shift, and future use. We consider the practical challenges associated with combining operations and data processes to result in a successful project. The implementation of a CMMS for a large consolidated program is no small feat and should be approached with much enthusiasm, broad discussion, plenty of consideration, reasonable flexibility, and some wishful thinking. It is our hope that this article could serve as a template or at least an ideas springboard for other CE departments undergoing expansion.

Background

In the fall of 2009, the Ministry of Health for the Province of British Columbia mandated the consolidation of the 4 biomedical engineering (BME) operations in the Greater Vancouver Regional District known as the Lower Mainland Vancouver. At the time, each BME department reported to their respective health authority: Providence Health Care, Provincial Services Health Authority, Vancouver Coastal Health Authority, and Fraser Health Authority. Over the next few years, the Lower Mainland Biomedical Engineering (LMBME) program evolved to a size of 180 staff supporting 90,000+ medical devices across 27 acute care hospitals and numerous clinics. In 2011, the LMBME

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program ventured to combine 3 disparate legacy CMMS databases into 1 new CMMS system. The decision to move toward a common CMMS was used as the key driver to rewrite business processes and implement change toward a common objective. The implementation of the CMMS for the consolidated program occurred in multiple phases over the course of 30 months. It is worth noting that our timelines were skewed because of an extensive legal review extending 6 months longer than anticipated.

The phases are broadly defined as follows: planning phase, evaluation and selection phase, pre–go-live phase, post–go-live, provincial expansion phase, and ongoing and future development (Table 1). The planning phase as well as the evaluation and selection phase remains out of scope for this article. In the fall of 2014, the CMMS was expanded to include 3 more health authorities (Island Health, Interior Health Authority, and Northern Health Authority) and their respective legacy databases to serve the entire Province of British Columbia. The CMMS is currently used by 350 staff that support 142,000+ medical devices.

Governance

A steering committee was formed in January 2011 and was composed of a director (leader), an engineer, a supervisor representative, and 1 technologist from each of the 4 health authorities. The steering committee reported to the executive director of the LMBME program, and its primary role was to prepare the data for migration and make decisions and recommendations in the best interest of the consolidated program, particularly during the planning and pre–go-live phases. Many of the steering committee's decisions are outlined in this article. This involved introducing basic fundamental changes to business processes and reshaping how the majority of technologists would use the new CMMS.

The health authorities unanimously decided that dedicated database administrators (DBAs) would best serve the ongoing needs of the CMMS as opposed to splitting DBA duties between part-time technologists. Post–go-live, 2 full-time and 1 half-time DBAs were hired for routine CMMS operations, and the CMMS steering committee was reshaped as an advisory body.

Vision for One System

The immediate need was to combine 3 disparate CMMS databases and create a common mindset for a functional system. The legacy CMMS programs had widely different database structures and captured different "relevant" information. The LMBME vision for our CMMS did not stray too far from the primary purpose of a CMMS[1,5]:

(1) a repository for assets;
(2) document history related to the assets:
  (*a*) WO and service history,
  (*b*) alerts management,
  (*c*) manuals,
  (*d*) service contracts, and
  (*e*) purchase order (PO) information;
(3) PM schedules;
(4) reporting capability;
(5) real-time reference; and
(6) parts inventory and usage history.

TABLE 1. Computerized Maintenance Management System Project Phases and Timeline

Phase	Tasks/Deliverables	Timeline
Planning	Brainstorm and vision sessions, evaluate integrity of legacy database and strategize conversion, redefine business processes	January 2011 to June 2011
Evaluation/selection	Define specifications, tender, evaluate off-the-shelf products, finalize contract	May 2011 to October 2012
Pre–go-live	Data cleaning of 3 legacy databases, data mitigation, fields and form customization, ongoing communication to biomedical engineering staff	April 2012 to April 2013
Post–go-live	Continued data cleaning, revision of controls on data input, periodic data integrity audits, and successive modules rollout	April 2013 to April 2014
Provincial expansion	Onboarding of 3 additional legacy databases, data cleaning, and policy and procedure alignment	April 2014 to December 2014
Ongoing and future development	Continued development of job procedures, reports, data cleaning, data audits, successive module rollouts	April 2014 to present

What Do We Want Out of the System?

The steering committee performed an analysis of how individual technologists and supervisors used the legacy systems, which provided a better understanding of how to move forward with a common CMMS. It was discovered

that individuals would put any information that they felt was relevant into the CMMS because "it might be important one day." The problem with this thinking is that the information that individuals input based on this assessment may not match the objectives of the consolidated program to record and report as a group. So, we started to ask the question: What do we want to get out of the system? Asking this question enabled two things, a fundamental shift in thinking to a broader perspective on the application of the database and a thorough understanding of what data we needed to put into the system. The steering committee decided early in our planning phase that if we did not understand what information we wanted out of the CMMS, then defining what technologists should enter into the CMMS was difficult. This question became so important that it governed many subsequent decisions made with respect to the CMMS implementation.

CMMS Access

During the evaluation phase, one of the mandatory criteria for the CMMS program was to have increased functionality using a Web-based interface. Our experience with legacy systems taught us that this method would best support the future direction of the program and is in line with general computing trends. The awarded vendor is 100% Web enabled, allowing access to the database from any personal computer (running Windows and .net framework) that has access to the Internet. This functionality enabled the accessibility required for a large regional program.

Our selected vendor also offered the option to host our database for an annual fee. We decided to pursue this option because hospital information technology (IT) was not a standardized service, having differences between regional IT group strategies, for example, network security (eg, IP reservations). We only required the IT group to enable an IP range and open ports to permit inbound and outbound communications, and ultimately this decision gave greater flexibility to our future expansion of the CMMS.

The vendor had a mobile application in development, but not yet available for testing during the evaluation phase. Even though our immediate strategy was not to use mobile technology for our workflow, we believed that having the option to expand to mobile technology provided good insurance moving forward.

Data Management

What Constitutes a Clinical Engineering Asset?

When the steering committee reviewed the legacy databases, it was apparent that each site applied different criteria as to what to include in the CMMS. The entry of an asset into the CMMS is the dividing line between agreeing to keep the whole asset record or agreeing to perform some cursory service, such as the incoming inspection while not maintaining the asset record. Often, BME programs are too quick to agree to do work on a device without considering the long-term ramifications. We had to take a fresh perspective on which assets to include moving forward. The steering committee developed a guideline that defines "what constitutes a clinical engineering asset?" and helps staff decide what assets are acceptable to enter in the CMMS.[10]

The Asset Record

The asset record must include a minimum amount of information to substantiate an asset. We adhere to a standard naming convention governed by a manufacturer-model pairing (eg, GE Healthcare: 5566025-230). This manufacturer-model pairing then creates a hierarchical link to the model name (Revolution EVO), category (scanning systems), subcategory (scanning system, computed tomography), and risk number (1—critical). There are a number of additional fields that form a complete device record.

It is well known that manufacturer's labeling systems vary,[11] and thus, entering the manufacturer's model consistently is not a trivial task.[12] We were quite aware of the variability in the labeling of medical devices between manufacturers and even among divisions of the same manufacturers, so we created a guideline to objectively and consistently determine a model for any asset (out of scope for this article). Manufacturer lists were combined from legacy systems and pared down so that we had only one of each manufacturer (eg, GE Healthcare, not GE Healthcare Canada and GE Medical, etc). The prevailing rule is that if a company acquires another the parent company then becomes the manufacturer in the asset record for all model pairings with that manufacturer. The ECRI vendor lookup was generally used to support our decision.

The ECRI Universal Medical Device Nomenclature System (UMDNS) helped define device type and device categories (eg, 13-468 scanning systems), improving the search capabilities of assets within the CMMS.

Data Entry Control

The steering committee understood the importance of data entry control. We also realized that process could not impede the technologists' workflow, or they would lose confidence in the system. We worked to strike a balance and allow technologists to enter new equipment with existing models already approved in the CMMS or some approved data fields. However, with 180 staff entering data, we needed to devise quality control strategies for data entry:

(1) Database administrators control the configuration of the CMMS, and form layouts create forcing functions of program at data entry including pick lists, drop downs, key mandatory fields lists, PM schedule templates, and common form layouts,

(2) Database administrators centralized data input to create and control new manufacturer-model pairings if they did not already exist in the database. Photographs of the faceplate and back-plate of the new model are required prior to entry in the CMMS for verification of the new model,
(3) Supervisor verification to approve data entered into the system by technologists
(4) Database administrators, through a variety of auditing processes, are the second check after the supervisor.
(5) Technologists are able to change uncontrolled fields such as serial number, IP address, equipment control number, and so on.

The decision to make data entry accessible to more people also meant more data auditing was required to discover inconsistencies in the data. Database administrators define and execute audits to clean up fragmented and inconsistent data. Results of any findings were communicated back to the supervisor.

Data: Consistency, Accuracy, and Completeness

After defining our manufacturer-model pairing, we used this list coupled with its device-type to clean and align the data between each of the legacy databases. The process to combine the databases followed the priority order of consistency, accuracy, and then completeness of the asset record.

Consistency was the primary focus prior to go-live combining databases. This required making a decision based on spreadsheet data to agree on the manufacturer-model pairing for each unique device, which forced interpretation of the existing data, and some similar models were lumped with others when they should have been be distinct (eg, CADDSolis and CADDPrizm). If different models from two different databases were similar, one had to be chosen to proceed (eg, CADDSolis or CADD2120). This was a necessary first step toward combining disparate systems, which happened during the planning and pre–go-live phase, but resulted in challenges for post–go-live as when CMMS users started looking up the equipment, it may have been incorrectly labeled.

Accuracy was emphasized post–go-live. This was achieved with the help of the eyes of all the staff. When equipment came to the department for repair, and known discrepancies between the data in the CMMS and the device were raised, the data administrators fixed the data to accurately reflect the true manufacturer-model pairing of the device, or any other core fields in the asset record. Also, they were careful to apply any changes throughout the database and to all similar devices, and not just to the device in question.

Completeness of the asset record is the long-term goal for data integrity. These are for fields that are in addition to the core fields in the asset record such as PO, MAC address, device alias, IP address, port number, and so on.

Culture

The culture around the use of the CMMS was one of the most difficult aspects of change in the planning and pre–go-live phases. We realized that even after go-live the culture requires ongoing care to foster positive results. Each health authority had developed unique work-related processes that had to be understood, analyzed, and reconstructed for a common business process. Some of the cultural shifts are explained below.

Time Recording

The committee made the decision that the CMMS would *not* be a time-recording system (ie, vacation, holidays, education leave, etc). We also decided that we would not enter "clinical time" (eg, education of nursing). All time entered into the WO in the CMMS must be directly related to an asset or a specific group of assets that are involved in the direct hands-on time to complete corrective work and PM so that the total cost of maintaining assets would be more accurately calculated.

Work Order Documentation

Work order documentation compliance required regular reinforcement, coaching, and explanation. Supervisors audited completed WOs and initiated monthly feedback with each technologist such as when to submit a WO, what information should be recorded in a WO, and when to enter the data alongside the repair. What they found was that some technologists did not provide sufficient information, and others provided far too much detail in their WO notes. Culture change was achieved by reinforcement of what constitutes relevant and irrelevant information for WO entry. We also introduced the question: What would someone else need to know to understand the work done in your WO? This personal approach helped technologists get on the right track and worked toward our goal to get consistent data going into the system.

There are a variety of ways that technologists would enter their data for WO completion. Some sites were storing WO entry on paper that would be entered once a week. Feedback from supervisors reinforced that WO accuracy is improved when data entry is done as soon as possible following work completion. The LMBME expectation is that WO entry should occur within a reasonable time, ideally in real time.

The DBAs also designed and created simplified WO forms, to include options for single-asset or multiasset WOs for the completion of corrective maintenance and PM. The database has also been customized for the logging and follow-up required for alerts management (out of scope for this article).

Our team knew that our clients would also like up-to-date WO status notifications as they moved through

TABLE 2. Additional Functionality and Modules

Functionality and Modules	Utility to Lower Mainland Biomedical Engineering Program	Status
Attachments	Provide detailed and specific referential information: purchase orders (POs), manuals, service contracts, end-of-life letters, warranties, terms and conditions of contracts, photos, Technical Procedures, etc	Active
Information technology (IT) information	Create IT-related fields for medical equipment on the hospital network (MAC address, IP, Firmware, etc)	Active
Preventive maintenance (PM) schedules	We use 3 priorities: critical, normal, and not scheduled	Active
	A PM engineer sets classification and schedules based on the device type	
	• The schedule priority and frequency are determined by device subcategory	
	• Similar device subcategory should have the same PM priority and frequency (exceptions by PM engineer approval)	
	Incoming inspection is a PM, next PM due based on this date	
	Staff can generate their own PMs in computerized maintenance management system (CMMS)	
	Every asset must have at least 1 schedule, and multiple schedules per asset are allowed	
Dashboard	Different information is displayed based on user profile supervisor, technologist, or management	Active
	Typical dashboard items	
	• Critical PM schedule overdue	
	• Critical PM schedule due	
	• Open PM work orders (WOs)	
	• Pending Web request corrective WO	
	• Open corrective WOs	
	• Open risk management WOs	
	• Pending new assets	
Canned and customized reports	CMMS has canned reports and the ability to create customized reports from the database	Active
	Examples of user reports	
	System administrator audit reports	
	• Asset without PM schedule report	
	• Asset subcategory not equal to model sub category report	
	Supervisor and management:	
	• Supervisor tech WO report	
	• PM compliance report	
	• PM percent completion report	
	• WO summary report	

Continued

TABLE 2. Additional Functionality and Modules, Continued

Functionality and Modules	Utility to Lower Mainland Biomedical Engineering Program	Status
	• WO summary report	
	Supervisor tech WO review report	
	Tech hour summary report	
	Finance reports	
	• Retired equipment report	
	• Parts usage report	
	• New asset report	
End-of-X information	Upload ''end-of'' manufacturing, support, and life information for each manufacture-model pairing	Active
Parts (module)	Three methods are used	Active
	• On the fly (active)	
	• Parts catalogue (in-progress)	
	• Parts inventory (future)	
PM job procedures	Develop standard PM procedures and checklists for each device type	In progress
	• All critical devices complete, recommended ongoing	
	• Integrate PM procedures into the CMMS	
Capital planning	Utilize the CMMS to aid replacement of medical equipment	Future
	Achieve consistency in purchase price, PO information, and contracts	
	Institute a replacement cost (not purchase cost)	
Service contract (module)	Alerts user when contracts need to be renewed	Future
	External service—warranty, time and materials, pro bono—upload service report within 72 h	
Decommission of medical equipment	A formalized job procedure to decommission medical equipment from clinical service and remove it from the CMMS	Future
Enhanced mobile access	Test and expand the use of mobile application to access the CMMS particularly for high-mobility technologists (eg, diagnostic imaging)	Future
Resource planning	Determine the average ''actual'' tool time per device type. This will better predict required resources	In progress

BME from a work request, to testing, waiting for parts, and return to clinical service. Our WOs allow multiple time charges from the same technologist or multiple technologists. It is expected that the WO reflect what was done at key milestones throughout the repair.

Supervisors' Meetings

The first year post–go-live, monthly meetings were scheduled to facilitate a dialogue between the steering committee and the supervisors. This allowed the steering committee to get feedback, to learn what worked and what did not work from the technologists' points of view and to disseminate information about upcoming changes, and to make collective decisions for the LMBME program moving forward. These meetings identified the need for common decisions that could be applied across the organization and not allow for silo operations. A considerable amount of time was spent for the administration, travel, and the discussion itself; however, reflection on this time confirmed it was time well spent gaining buy-in to the direction of the CMMS.

Alerts, Hazards, and Recalls

Amalgamating databases meant that we no longer required multiple people managing alerts, hazards, and recalls for each CMMS system. Having consistent, accurate, and complete data requires only one DBA to monitor all alerts from any source such as ECRI, Health Canada, US Food and Drug Administration, and vendors. The DBA is able to confidently query the database, determine all assets that apply to the alert, and then open a multiasset WO for documentation.

Privacy and Security

No patient identifier information or LMBME staff personal information that is not already employer information (eg, technologist names and employee number) is entered into the system. The Province of British Columbia implemented a provincial patient safety reporting and learning system, which has a secure database, designed to house patient-sensitive data from adverse events.[13] The CMMS software is not intended nor is it designed to store this information. We wrote a policy to enforce CMMS privacy, and an audit is done quarterly to ensure compliance.

Online Web Request

This system enables our clients to submit online Web requests for corrective repair for medical equipment. The requestor, typically a unit clerk or nurse, can submit a request online, which then automatically opens a WO in the CMMS. This system also provides the ability for the requestor to query any of their requests to determine its current status (eg, waiting for parts). Surprisingly, there was considerable resistance from technologists to implement this system. Perhaps it was because initially the onus was on the technologist to remind and inform the requestor to use the online system rather than traditional methods such as in person or phone calls, and they may have felt it would compromise their reputation for providing outstanding personal support. Following rollout, it is also important to seek and remove all previous forms and fax memos from clinical areas and local intranet. We drafted "how to" and frequently asked question guides and posted them electronically to aid the completion and submission of the online Web request.

Future Use

Go-live of the CMMS focused on delivering the core requirements for a technologist to perform his/her work. Additional ideas and modules providing enhanced functionality have been incorporated. The status of each function or module is summarized in Table 2.

Discussion

One of the upcoming challenges for the advisory body is to adapt to the US Food and Drug Administration's unique device identification (UDI) system. This system will provide medical devices with a unique standardized identifier in the form of an alphanumerical code specific to the version or model of the device.[14] In general, the benefits of this system for CE departments are to target device recalls and corrective actions for devices and also to simplify adverse event reporting.[15] We believe it will also have the benefit of increasing data integrity by removing subjectivity of selecting model and the UMDNS codes. Consequently, our group will most likely abandon the UMDNS nomenclature for the Global Medical Device Nomenclature system that is adopted by the UDI system (GUDID Reference). Preliminary discussions within the CE community are already underway[16]; it will be exciting to see how this changes our CMMS for the better.

Conclusion

The CMMS remains the core of any CE program. The LMBME planning and pre–go-live of the CMMS provided structure for conversations about business processes, operational requirements, technology management, and support of clinical services. Herein, we documented our defined vision for 1 system and discussed some of the practical challenges associated with combining operation and data from disparate CMMS systems into 1 database. We considered our data management strategies to ensure data integrity, quality, and consistency and discussed our renewed culture to align BME practices and dream toward future uses.

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