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Optimizing the CMMS *Failure Code* Field

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Advancing Safety in Health Technology

ABOUT AAMI

The Association for the Advancement of Medical Instrumentation (AAMI), a nonprofit organization founded in 1967, is a diverse alliance of more than 9,000 members from around the world united by one critical mission—supporting the healthcare community in the development, management, and use of safe and effective medical technology. AAMI serves as a convener of diverse groups of committed professionals with one common goal—improving patient outcomes. AAMI also produces high-quality and objective information on medical technology and related processes and issues. AAMI is not an advocacy organization and prides itself on the objectivity of its work.

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Introduction

Computerized maintenance management system (CMMS) software has become essential for healthcare technology management (HTM) program operations. Sophisticated CMMS databases allow the collection of vast amounts of data and offer the promise of providing actionable management information.

However, frontline HTM professionals sometimes regard their interaction with the CMMS as an onerous data entry chore. Managers of HTM programs sometimes struggle to derive useful insights from the mountains of data despite the tremendous capabilities that CMMS suppliers have built into their products.

In response to this challenge, the Association for the Advancement of Medical Instrumentation (AAMI) sponsored a "CMMS Collaborative" project among CMMS suppliers. The project started with an assumption that better use of existing CMMS software would make it easier to get accurate data into the database and useful information out of it.

Background

As HTM professionals, we are familiar with the lack of standardization in CMMS configuration. All modern CMMS software contains the fundamental fields that are needed for basic HTM program operations. Unfortunately, HTM programs differ widely in how they configure those fields.

In some cases, the chosen configuration makes it difficult for HTM professionals to enter data and to extract information. That limits the ability of the HTM program to operate economically in its efforts to provide safe and effective medical technology for patient care.

More broadly, the lack of standardization makes it virtually impossible for the HTM community to engage in benchmarking. Performance metrics from one HTM program often cannot be compared to metrics from another HTM program. Moreover, this puts the HTM community in a weak position relative to regulatory and accreditation agencies. Without performance metrics that are representative of HTM programs across the country, the HTM community cannot support its assertions about what works and what doesn't. Effective advocacy requires good data.

Over the years, the HTM community has engaged in informal debates—also known as "flame wars"—without much progress toward consensus. Organizations like AAMI and ECRI have offered benchmarking tools that largely failed because HTM programs had difficulty providing consistent data. AAMI has also developed formal standards such as ANSI/AAMI EQ56:2013, *Recommended practice for a medical equipment management program*, with limited impact on HTM program operations.

With these considerations in mind, a group of leading CMMS suppliers (Table 1) met informally at the 2019 AAMI Exchange with AAMI representatives and a small number of HTM thought leaders. The purpose of the meeting was to discuss the feasibility of a collaborative effort and a new approach to standardization.

Table 1. Participating CMMS Suppliers

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

The new approach to be taken by the CMMS Collaborative was more of a "build it and they will come" effort. Suppose the leading CMMS suppliers could reach a consensus about how to configure key CMMS fields. They would rely on their vast experience with data collection and their strong working relationships with clients: Offer useful tools to HTM professionals and they'll use them.

A project charter was written to define the rules of engagement and scope of work: standardization of selected CMMS fields. CMMS suppliers would support their clients through reconfiguration of existing CMMS installations and as part of new CMMS implementations. AAMI would provide administrative and financial support.

We learned two things early in our discussions:

1. HTM program managers—the clients of the CMMS suppliers—look to the CMMS suppliers for advice on how to configure their databases. They say, "Tell me the best way to set up my CMMS."

2. CMMS suppliers—who offer tremendous flexibility in database configuration—look to HTM program managers for direction in database configuration. They say, "We can set it up any way you want it."

The practical objective then became development of recommendations for CMMS database configuration that were feasible from the perspective of the CMMS suppliers and responsive to the needs of HTM professionals for easy data input and useful information output.

The *Failure Code* Field

The CMMS Collaborative project members quickly reached the conclusion that the *Failure Code* field would be the focus of the standardization effort. The rationale for this decision was heavily weighted on the field's importance to the design and implementation of an alternate equipment maintenance (AEM) program.

Moreover, the ability to track and analyze medical equipment failures would support monitoring and improving the entire planned maintenance (PM) program, leading to safer and more effective medical equipment.

All comprehensive CMMS databases contain one or more fields that are used to record failures, reasons, results, or other data related to medical equipment work orders. An audience poll conducted during an AAMI HTM*Live!* webinar[1] confirmed that there is wide variability in how failures—a description of what went wrong—are defined and documented (Table 2). The various CMMS databases used by those in the audience had a variety of fields, sometimes multiple fields in a single database, that were used for collecting failure-related data.

Table 2. AAMI HTM*Live!* Webinar Polling Question 1

Responses	What fields does your CMMS have that can contain failure data?
71%	Failure Code
62%	Reason or Problem Code
52%	Closing or Result Code
17%	Other

The *Failure Code* field, as conceptualized for this project, is intended for use with all PM and CM (corrective maintenance) work orders, which are the two work order types in which equipment failures are encountered. It is not designed for use with other work order types (e.g., incoming inspection, administrative and planning activities, etc.), because these typically do not involve failures. For reasons discussed in more detail below, the *Failure Code* field should not be used to record work order outcomes that do not represent medical equipment failures (e.g., Could Not Locate).

The decision was also driven by the fact that the HTM community has been rather inconsistent in how they use the *Failure Code* field, how they configure it, what data they put into it, and what they do with those data. It was agreed that the field and data within it could not readily drive management decision-making because of the inconsistencies. Therefore, an early project task was to look at the different ways this field is used as documented in various CMMS databases.

Supporting Analytics

Superior Analytics (a subsidiary of Phoenix Data Systems) aggregated data from 2.5 million work orders from Phoenix Data Systems' AIMS clients and other CMMS platform databases to visualize what entries are being made in failure code–related fields (Table 3). The first thing we noticed was that thousands of entries were not relevant in the sense that the entries—although representing essential data—did not describe failures (e.g., Cannot Locate) and were not relevant to failure analysis; therefore, they should not be documented in the *Failure Code* field but should instead be collected in other fields.

Table 3. *Failure Code* Crosswalk

Superior Analytics Consolidated List of Result Codes	Comments	CMMS Collaborative Draft List of Failure Code Options
Administration	Not a failure. Use a different field.	
Cannot Locate		
Device in Use		
Device/Asset Disposition		
Dirty		
First Response/Triage		
Hazard/Recall		
Incident Investigation/Report		
Initial Inspection		
Repeat Problem		
Training		
Alarm Issue	Failure *indicator* only, not a failure.	
No Code Assigned	Make *Failure Code* a required field.	No Failure Associated with the WO
Abuse/Damage	Equivalent ⇨	Failure Caused by Abuse or Negligence
Battery Issue		Component Failure (Battery)
Calibration		Calibration Failure
Network Issue		Network or Connectivity Failure
No Problem Found/Cannot Duplicate		Failure Could Not be Identified
Operator Error		Use Error
Software Issue		Failure Caused by Software
Electrical Issue	Combine ⇨	Failure Caused by Utility System
Power Issue		
Device Failure	Break out by cause ⇨	Accessory Failure
		Component Failure (Not Battery)
		Failure Caused by Maintenance
		Failure Caused by Environmental Factor
		Permanent Failure—Device Not Repaired

WO = work order

This led to the next project task of defining the purpose of the *Failure Code* field in a manner that would be clear to frontline staff (i.e., technicians and engineers) and result in accurate data collection through the use of standardized field options that are *mutually exclusive* and *exhaustive*.

The purpose of the *Failure Code* field is to document the reason that a medical device was unable to achieve its clinical objective of diagnosis, treatment, or monitoring. This would include obvious failures that blocked achievement of a clinical objective and latent (hidden) failures that could have (and eventually *would* have) blocked achievement of a clinical objective.

The term *mutually exclusive* means that the options do not overlap and that there is only one appropriate choice. This contributes to consistency in data collection by reducing the number of potential choices about how to complete a particular work order. The term *exhaustive* means that the options cover all possible situations. To support comprehensive data collection for the *Failure Code* field, which is essential for its use in maintenance management, the field should be configured as a required-input field. This requirement can be made only if the field options cover all possibilities.

During the HTM*Live!* webinar, we asked how well the audience's HTM programs met these database design criteria (Table 4). Clearly, a substantial number of failure code implementations fall short on one or more of the criteria.

Table 4. AAMI HTM*Live!* Webinar Polling Question 3

Responses	How well does your *Failure Code* field meet these criteria?
73%	Purpose of the field is clearly defined
32%	Options are mutually exclusive
41%	Options are exhaustive
59%	Failure code data routinely analyzed

In addition, the number of *Failure Code* field options needs to strike a balance between practicality (ease of use) and granularity (information detail). This requires a trade-off between too many choices (burdensome for technicians) and too few choices (lacking the degree of specificity needed for management decision-making). Our recommendations (Table 5) include a total of 14 *Field Code* options. Another HTM*Live!* audience poll (Table 6) suggests that this is an acceptable number.

Table 5. *Failure Code* Field Options

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.
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

Table 6. AAMI HTM*Live!* Webinar Polling Question 2

Responses	Are 14 recommended options too many or too few?
15%	Too many options
70%	A reasonable number of options
15%	Not enough options

Recommended Standardization of Failure Code Options

The analytics described above provided guidance for differentiating between types of failures. For example, the quantity of battery failures implied a need to differentiate those failures from the failure of other types of components. This differentiation enables HTM management decisions specific to battery management protocols (e.g., battery replacement schedule) as compared to the wide variety of other component failures (that often tend to be random).

Additionally, it was determined that failures related to use (e.g., misuse, abuse) should be differentiated from technical failures. This differentiation enables HTM management decisions that address user competency versus PM effectiveness. Other required points of differentiation include failures caused by environmental conditions or utility systems as well as situations in which the problem cannot be verified (i.e., could not duplicate).

The CMMS Collaborative group's recommended *Failure Code* field options are summarized in Table 5. For each option the table contains recommended terminology, a concise definition, and brief examples.

To determine the practicality of the recommendations, we spent substantial time reviewing blinded data sets provided by the CMMS suppliers. These data sets included hundreds of line items of closed CM and PM work orders and were compared to the proposed list of failure codes to see how well they could be applied. As a result of this process, we found situations that were not clear or that represented gaps (e.g., there was no failure code available for that situation). Table 5 incorporates what we learned from this process.

Table 5 also indicates (by red check marks) which failure types are PM related. By "PM-related" we mean failures that can be mitigated by better PM. There are two categories of PM-related failures:

- Failures that could have been prevented by better PM.[a]
- Failures that could have been discovered by better PM.[b]

Used in this way, the *Failure Code* field can identify opportunities for improvement by characterizing equipment failures in a manner that informs efforts to mitigate those failures.

In a small number of work orders, there is a possibility that more than one failure code option could be applied. For example, if equipment abuse caused a non–battery component failure, either the "Failure Caused by Abuse or Negligence" option or the "Component

[a] For example, early failure of an infusion pump battery. The *Failure Code* field option would be "Component Failure (Battery)". Better PM might include more frequent battery testing or replacement.

[b] For example, a finding that the output of a defibrillator was inadequate at lower settings. The *Failure Code* field option would be "Calibration Failure". Better PM might include testing defibrillator output at both lower and higher settings.

Failure (Not Battery)" option could be applied. In such cases, the selected failure code option should be the one that represents a root cause—a fundamental cause rather than a symptom or consequence. By that reasoning, the former code would be preferred over the latter.

Examples of Applying the Standardized Failure Code Options

The *Failure Code* field can also be used for monitoring the performance of an AEM program. For example, the standard MTBF (mean time between failures) metric, which is calculated for failures of all types, can be supplemented by an $MTBF^{PM}$ (mean time between PM-related failures) metric that is based on only PM-related failures (i.e., those failures that can be mitigated by better PM). In addition, configuring the CMMS to flag PM-related failures can provide an early warning for emerging maintenance issues, allowing proactive adjustment of maintenance practices.

For example, if work orders with the "Component Failure (Battery)" failure code begin to appear, this can serve as a red flag to review PM procedures for potential improvement. Some premature battery failures might be mitigated by better PM (e.g., adjusting the battery replacement schedule) but others might not (e.g., ensuring all infusion pumps are plugged in often enough for adequate charging). The value of the red flag is that we are alerted promptly to a situation that potentially can be improved.

Use of standardized failure code data can also promote the discovery of hidden (latent) failures that could have been discovered by better PM. For example, suppose a defibrillator has a hidden failure that caused it to have low energy output. Device users may or may not have a sense that there's a problem with the defibrillator. Only an HTM professional with specialized knowledge and test equipment can recognize the problem. That, of course, is why HTM programs spend so much time and effort verifying equipment function. An important aspect of PM program management is to know which tests are worth performing (and how often) and which are not. Collecting accurate failure code data is essential.

The use of standardized failure code options can also identify non–PM-related issues that might be resolved by appropriate action. Some examples:

- If a user drops an infusion pump, doing more PM won't fix the problem; the root cause of the failure is mishandling of the device. This could of course represent an isolated incident, but repeated incidents may indicate a need to evaluate the specific circumstances: Under what conditions are the pumps dropped? During cleaning? During transport? During setup at the bedside?
- If the drug library for the infusion pumps is not updated, that may not be an actual failure of the pump, but rather a failure of connectivity or some other issue that allowed the pump to retain an outdated library.
- If a user incorrectly programs an infusion pump, this does not reflect a failure of the pump to work properly. Rather, this may indicate a need for additional user training, device configuration adjustments, or even replacement with pumps that are easier to use.

Conclusion

To facilitate adoption, the CMMS suppliers have committed to working with existing clients to determine pathways and tools to transition from current platform configurations to ones that leverage this standardized list of failure codes. These failure codes enable the sort of metrics and analytical work needed for HTM operations and performance improvements. Additionally, the CMMS suppliers will support new clients with platform configurations that immediately leverage the standardized failure codes.

The CMMS Collaborative members gratefully acknowledge the contributions of many reviewers. We received numerous written comments and had many conversations, all thoughtful and based on hard-won experience. This document incorporates many of those contributions.

We also heard from several HTM professionals who plan to implement the CMMS Collaborative recommendations in their own CMMS databases. AAMI will monitor adoption of these standardized failure codes throughout the HTM field and solicit feedback from those who have implemented them. If you have questions about how to implement this set of failure codes or have feedback, please email HTM@aami.org.

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Reference

1. HTM*Live!* Getting the CMMS to Work for Us (instead of the other way 'round): Optimizing Failure Codes. June 2020. attendee.gotowebinar.com/recording/9193177656014558735.

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