To get the most out of its preventive maintenance (PM) activities, Technical Services Partnership (TSP) at the University of Vermont first needed to determine the failure rate for various types of healthcare technology. This massive undertaking, deemed the Comprehensive Preventive Maintenance Frequency Adjustment Project, would provide TSP with the data it needed to optimize equipment maintenance schedules based on overall risk.

TSP operates as a not-for-profit department within the university, providing clinical engineering services to around 30 hospitals, clinics, and other healthcare delivery organizations in Vermont, New York, and New Hampshire. The majority of facilities in the TSP network are small community hospitals (100 beds or less), but it also includes larger regional institutions, such as the University of Vermont Medical Center. TSP helps its customers stay current on the latest advances in healthcare technology while ensuring patient safety, clinical efficacy, cost containment, and operational excellence.

TSP has two primary staff positions: biomedical equipment technicians (BMETs) and clinical engineers. The BMETs are in residence at the various hospitals (community and teaching), performing frontline medical equipment safety and performance inspections, while the three full-time clinical engineers provide oversight for large geographic areas, including assessing the clinical efficacy of new equipment, conducting incident investigations, completing electronic medical record–equipment integration projects, and ensuring compliance with regulations and standards.

**Challenge**

“This project was a very deep dive looking at our PM program,” said Michael Lane, MBA, CMgrQ, associate director at TSP. “Every biomedical engineering department evaluates work orders and determines failure rates, but we found very little published information available.” Luckily, owing to its vast network, TSP has access to a wealth of information. Drawing inferences from that information, however, would require a good deal of elbow grease.

“Since about 2005–06, we had not done any major assessment of our PM schedules,” said Leah Francoeur—a clinical engineer whose primary focus is on TSP-affiliated hospitals in New York State. “We were due for a comprehensive assessment of our maintenance records. Essentially, this task was undertaken to answer the question, ‘What are we doing to make sure the equipment runs better?’”

Targeting a three-year period (from January 1, 2009, through December 31, 2012), the group extracted more than 33,000 work orders from its computerized maintenance system (HEMS Enterprise from EQ2) in spring 2013.
Solution

“As part of our BMETs’ routine inspection and PM of medical equipment, they identify and document failures within our computerized maintenance system,” explained Tobey Clark, director at TSP. The techs are required to create a work event in the system and apply coding that identifies whether the issue is, for example, maintenance related or a critical failure.

Clark noted that PM directives from the Centers for Medicare & Medicaid Services (CMS) in early 2013 helped spur on the project. “The increased attention from CMS was a definite motivator. We saw this as a good opportunity to reassess how we were looking at our PM activities,” he said.

As TSP began its initial analysis of the data, issues related to the coding of work orders quickly surfaced. “In certain instances, staff were not coding the work orders correctly, so we didn’t have an accurate portrayal of whether certain events were, for example, maintenance related, critical failures, or battery-related failures,” said Lane.

This discovery prompted TSP to undertake a painstaking process of reviewing every work order over the three-year span of study to ensure that the codes were accurate and that the type of failures identified matched the group’s definitions. To help crunch the numbers, TSP enlisted the help of its clinical engineering interns, who are employed by the organization for five- to six-month terms.

Concurrent with this process of auditing the work order codes, TSP began educating its frontline BMETs. “We have very detailed definitions and codes, but as with any database, relationships cannot be revealed unless the information is accurate,” said Lane. TSP therefore set to work on banishing these “garbage data” by ensuring that its techs had a clear understanding of the meaning and application of work order codes.

Results

After the reclassification process was complete and TSP had confidence in the integrity of its data, the group set to work on determining the failure rate for various types of equipment.

“We catalogued the failure rate by risk category,” said Lane. “We have a system in which a risk score is assigned to equipment based on a scale of 0 to 18. Any piece of equipment with a score of 13 or higher is considered high-risk equipment. The bulk of the equipment we support is in the 9- to 11-point range.”

The result was an evaluation of 502 equipment types affecting 66,648 devices. An algorithm was developed to either increase or decrease the inspection frequency based on the calculated failure rate.

Using data-based modeling, TSP looked at proposed failure rates to elucidate the impact on its PM activities. For the three-year period selected for the project, an actual overall failure rate of 5.5% was determined across all equipment types. However, TSP identified a desired rate of 5% as its goal moving forward.

“Working as a team, the clinical engineers debated how low the failure rate could reasonably be set while keeping staff workload at a reasonable level,” said Lane. “We had modeled as low as a 2.5% failure rate, but there is a clear point of diminishing returns related to PM activities. We eventually settled on a conservative drop to 5%.”

Francoeur emphasized that the 5% failure rate will be revisited as TSP gains more data and experience. “Our goal, like most clinical engineering departments, is to maximize equipment uptime and patient safety while minimizing costs. As we examine the results of our implementation, we will continue to
monitor failures by risk category and determine if future adjustments are warranted,” she said.

TSP’s next step was to analyze the impact that this goal 5% failure rate would have on all device types under consideration. “We collaborated with our BMETs to figure out how changing the frequency of PM for certain equipment would affect the overall failure rate,” said Lane. “Through that process, we learned that the testing frequency for certain devices would need to increase, decrease, or stay the same.”

“In addition to data analysis, the clinical engineering team gathered feedback from the BMETs in order to make a final determination of PM frequency,” he added. “The designated changes in frequency were systematically reviewed by clinical engineers and a new frequency assigned.”

Using anesthesia equipment as an example, Francoeur illustrated one instance in which PM frequency was revised.

“Anesthesia machines are high-risk devices. As a result, the number of maintenance-related work orders for these machines is quite high. Although we perform PM on anesthesia machines three times a year, which is more than the manufacturer recommends, our analysis of the data showed that this still wasn’t enough. We found that a lot of user-related maintenance either wasn’t getting done or wasn’t getting done in a timely fashion. For instance, oxygen sensors had not been calibrated in a timely manner and flow sensors, which are user-replaceable items, had started degrading, resulting in flow leaks.”

Before the PM project had begun, TSP had planned on decreasing the PM frequency of the anesthesia machines to twice a year. This would have put the PM schedule in line with the manufacturer recommendations. However, based on data analysis, TSP decided to keep the PM frequency for anesthesia machines at the current rate of three times a year.
“We will continue to work with our clients and anesthesia providers to decrease failures due to user maintenance,” said Francoeur. “Once the maintenance data show that user maintenance is under control, we’ll revisit the anesthesia PM frequency to see if it needs revamping.”

Francoeur also explained how the overall process of revamping PM schedules has itself required continual tweaking. “We really needed to wrap our heads around the need to increase PM for certain devices. When we began the project, our initial thought was that overall, we would be doing less PM. But as we analyzed the data, we discovered that for certain types of equipment, that just wasn’t the case—we needed to do more,” she said.

Francoeur highlighted how the BMETs were the backbone of the project. “Day in and day out, they’re the ones servicing the technology, so gaining their feedback on the changes we were considering was essential.”

She also offered insight into the relationship between PM and failure rates, noting that they are tied together but not necessarily in a linear relationship. “You may not see any drop in failure rates for a device by simply increasing your PM frequency from once a year to twice a year,” said Francoeur. “It also is true that many failures cannot be avoided by maintenance, but our maintenance records show that performance inspection is detecting problems with the equipment that are not otherwise being reported to biomed.”

As a result, added Lane, “changing PM frequency is not a ‘set it and forget it’ type of initiative. We will need to revisit the schedules regularly to make sure they are optimized.”

The robust data being collected by TSP also have important tie-ins with CMS’s Alternate Equipment Maintenance (AEM) program. “With the AEM program, CMS is requiring that your maintenance program be based on sufficient maintenance data. That is what we are trying to do with our program—use the data analysis to justify modification of our maintenance schedules,” explained Francoeur.

Moving Forward
To roll out implementation of the project, TSP has devised a communication plan for each of its sites. “As we roll out this new PM program, an important step is making sure our hospitals understand that we are not taking away maintenance hours. Instead, we’re changing where our BMETs’ hands are going,” explained Francoeur.

“Time constraints and doing more work with less resources is a key component,” she added. “So the idea here is ‘right sizing’ our PM program and getting our BMETs to focus their efforts on the equipment that will have the most impact, rather than mindlessly performing functional tests on a set basis year after year.”

To increase visibility, TSP also has begun including the due date for the next PM action on stickers affixed to each device. “At the end of the day,” said Francoeur, “maximizing the reliability of medical equipment is the main goal of this project.”

Lane also is hoping that TSP’s project will motivate other groups to take on—and moreover report the findings of—similar initiatives. “When we started this project, we were interested in learning about established failure rates, but a dearth of such data exist in the literature,” he said. “Now that we have established a goal failure rate of 5%, we would be very interested to see how that stacks up with the findings of other entities,” he said.

Clark underscored that a project such as this cannot get off the ground unless cohesion exists across the clinical engineering team. “This was a huge project that required making sense of massive amounts of data, and it would not have been possible without the amazing team effort among our BMETs, clinical engineers, and interns. We’re very pleased with the results thus far. Ultimately, basing decisions on robust data is going to have a positive ongoing effect on our PM activities, which will in turn allow our hospitals to deliver high-quality patient care,” he said.