Navigating a Sample Installation

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Introduction

One may define navigation as a way to plan, record, and control the course and position of a ship, venture, or project. Another definition may be - to make one's way through a difficult path, such as a storm or a crowd. As NSTAR ventured into a new sample installation this past year and this year, its navigation intent was no doubt the first definition. However, NSTAR has encountered a few storms in the process.

This paper reviews the course NSTAR took in its most recent sample installation. It discusses the background, the selection of meter and communication technologies, the pilot and its results, the measurement of the sample installation success, and the status of the installation process to date.

Background

When NSTAR performed a cost-of-service study for a 2005 rate case, load research data was not available for the necessary test year. The sample installations deployed in the 2000-2002 timeframe were not completed as planned due to many obstacles including merger activities, alpha technology failures, poor communication installation procedures, and numerous management changes. These challenges resulted in significant data loss and the load analysis could not be developed for the rate case test year.

Knowing that its load research data is also being used for another critical function, load estimation and reconciliation for ISO New England (ISO-NE) wholesale market settlement, NSTAR performed in October 2005 an assessment of its load research program to determine the status and health of its existing load research samples. Based on the assessment, NSTAR initiated the replacement of its failing samples.

The assessment showed that:

- The age of the samples were over nine (9) years old, far greater than the industry standards of three (3) to five (5) years;
- NSTAR experienced significant data loss of approximately 47 percent (%) due to meter and communication failure, incomplete sample installations, and slack data acquisition practices compromising the samples;
- The sample design and size specifications were insufficient to achieve accuracy of +/- 10% at the 95% confidence level commission requirements;
- Sample bias occurred in the installation process where only sample points with easy access were installed. With over fifty (50) % of NSTAR's meters indoors, alternates were selected based on their outdoor accessibility;
- The accuracy of the sample results was poor. The relative precisions for the 2003 results averaged from 20 % to over 30 %.

The Interval Data Meter Project

The sample replacement initiative coincided with the Interval Data Meter (IDM) project. NSTAR initiated the project to address its short-term and long-term interval data meter strategy, in particular, the impact of the 2005 Energy Policy Act (EPAct) and the replacement of its load research samples. The intent was not only to solve certain short-term issues, but also to develop a long-term metering strategy that would optimize the data acquisition function, meter and communication life in the most cost-effective way. This approach included a collaborative effort between several functional areas, including Load Research, Meter Operations, Data Acquisition, and Information Services.

The objectives of the IDM project team were to:

- Mitigate 2005 EPAct Daylight Saving Time (DST) change impact
- Update load research samples for regulatory compliance
- Mitigate risks related to older ISO interchange meters with expiring 20-year DST programs
- Implement TOU AMI on older meters

The IDM team evaluated new interval metering and communication technology. As part of the evaluation process, the Team issued a request for information (RFI) during the 1st quarter of 2006 and invited vendors to present their metering and communication solutions. The Team evaluated the RFI responses based on the following key requirements for its load research samples:

- Ninety (90) days of 15-minute kWh interval data at the meter with status flags
- Meter platform and metrology must perform remote updates and self diagnostics

- Midnight self meter reads forward at a predetermined schedule
- Security from tampering over communication channels to the data collection server and over public networks
- Two-way communication
- Ability to export data in groups automatically in any common MV-90 format

The Meter Operations performed initial meter lab tests on the possible technology solutions. What was found during the evaluation is that wireless "under the glass" metering solutions are evolving, with different meter manufacturers partnering with 3rd party's for their wireless communication hardware. There are no large scale deployments of wireless technologies in the industry.

Metering and Communication Technologies

The IDM team selected two major 2nd generation wireless technologies; GPRS (General Packet Radio Service) and 1xRTT (Radio Transmission Technology). Both are more commonly referred to as Cingular (GPRS) and Verizon (1xRTT) wireless.

The primary solution consisted of SmartSynch GPRS Cingular communication module with the Elster A3 meter, while the alternate solution consisted of the Trilliant 1xRTT Verizon communication module with the GE KV2 meter. Since the overriding concern for the sample installation is coverage, two wireless technology solutions allowed NSTAR to use the solution with the best coverage at a particular site.

Another factor for the meter and communication technology selection was the accessibility of meters. In particular, the sample meters are installed primarily on residential customers and small commercial and industrial customers, who have meters indoors. Residential customers are less likely to allow NSTAR access to their indoor meter for meter reading and exchanges. The meter and communication technology solutions selected allow for this remote access to the data with the wireless capability and allow for nightly data downloads for interval data as well as off-cycle reads when needed.

Another important factor was the ability to secure data transfer to the NSTAR billing system. Currently, GPRS technology through NSTAR's existing SmartSynch's TMS server is the preferred solution since it addressed Information Services' concerns about data being sent directly through the NSTAR firewall and minimized the need for additional system implementations.

The Pilot

A pilot is defined as:

"to act as a guide to**:** lead or conduct over a usually difficult course"

– Merriam-Webster Dictionary

In 1620, 102 pilgrims sailed to Plymouth Massachusetts, a town in NSTAR's territory. Although the first half of their voyage was smooth sailing, the Mayflower encountered a number of bad storms in the second half of the voyage, making the ship very leaky and causing many of the passengers to become sick. Two passengers died during the voyage. The pilgrims may have been better prepared if they had piloted a shorter trip to determine the seaworthiness of the ship before their longer voyage across the Atlantic Ocean. However, nothing would have prepared them for a New England winter. Half the pilgrims died during their first winter.

Although the IDM team was much better prepared for a typical New England winter than the pilgrims, the Team determined that it needed to perform a pilot on the selected technologies to understand the technologies' implementation feasibility on a larger scale. NSTAR's experience with sample installations had been problematic in the past and it did not want to follow in its ancestors' footsteps. The pilot focused on minimizing any issues that could arise in full scale deployment.

Pilot Objectives

The objectives of the pilot were to:

- Assess metering and communication technologies for remote interrogation of interval meters and for a long term interval meter strategy
- Test and install the technologies and identify potential implementation problems and issues
- Recommend metering and communication technologies to implement for NSTAR's overall interval meter population
- Map out set-up processes and train resources for full scale deployment

Pilot Frame Specifications

The Cambridge Electric (CAMB) R-2 sample and the Boston Edison Electric (BECO) R-2 sample were chosen as the frames for the pilot because of their small sample sizes, 81 and 82 respectively, and small population sizes, 1703 and 33,165 customers respectively. Their combined impact on total population level estimates is quite low.

As part of the sample design and selection process, Load Research created alternate lists in addition to the primary selection lists. These alternate selections were used in place of a primary selection, if the installation of the primary selection was deemed infeasible. Load Research provided alternate points for installation after all efforts had been exhausted in attempting to install the selected primary sites.

Pilot Evaluation Criteria

During the pilot, the Team evaluated the viability of the metering and communication technology and the establishment of proper processes and procedures using the following business and technical evaluation criteria:

- Customer Access

Customer access is a key factor to a successful installation. The pilot provided the opportunity to review the normal business process when requesting customer access. For example, callbacks to customers for scheduling appointments required a special script, since many of the selected customers had recently experienced a meter exchange due to the mass market AMR deployment.

- Data Retrieval Rate > 95%

One of the key business criteria is the acquisition and retrieval of data. The rate is based on the amount of good data that the end use customer (Load Research) receives in a timely manner. In the last sample installation, a good portion of the meters passed data to the data acquisition software; however, the data did not reach Load Research.

- Cost of Data Acquisition

The cost of data acquisition was a major concern for management, since the cost for NSTAR's pager -equipped meters was quite high. Our data acquisition group spent considerable time negotiating with wireless carriers to ensure that the costs were as low as possible.

- Meter Accuracy

The pilot meters were tested for both accuracy and communication success. Accuracy testing was done per existing meter standards which follow ANSI/ASQC guidelines for lot size and prior accuracy history. The communication modules were tested at 100% to insure that only coverage issues remain for successful field installation.

- Ease of Meter Installation

The ease of installation was a function of multiple criteria, such as customer access, and communication signal. This criterion focused on the technical aspect of the meter installation. The Meter Operations determined how best to preprogram the meters whether in the field or at a central location. Additionally, this criterion focused on ensuring the meter technicians have the appropriate tools and equipment to perform the installation smoothly.

- Establishing a Communication Link

Establishing the communication link addressed how easy it is to link the meter to the data acquisition software. The link had to be relatively seamless with minimal effort from the field and Data Acquisition group.

- Strength of Communication Signal

The meters were tested in the socket for signal strength and communication to the data acquisition server at each site. If the communication signal was considered unsatisfactory, the alternate technology was tested. If the signal was still unsatisfactory, the original AMR meter was not replaced and an alternate site was used instead.

- Security

The meters had to be secure from physical tampering. The communication channels were secure from tampering to the data collection server. Communication to and from the meter and data collection server were protected (encrypted) to prevent tampering.

- Remote Access

This criterion evaluated the set up of remote via the data acquisition software, testing the two-way communication ability to push data daily, perform test diagnostics and have the meters call home if there is a problem.

Pilot Findings

The pilot evaluation identified the following findings:

- A high percentage of alternates were being used because the communication module antennas were not strong enough to achieve the necessary signal strength for successful data transmission. NSTAR proactively worked with the vendors and had the meters retrofitted with antennas seventeen times the strength of the original antennas.

- The pilot also identified improvements to the provisioning of the meters during the initial set-up process.
- Formal communications protocols were established with customers to set-up times for meter installations, since approximately fifty percent of NSTAR meters are indoors.
- Original estimates for setting up the meters in the data acquisition systems were low. Additional staff was employed to assist in the effort.
- During the pilot and sample installations, NSTAR also updated its data acquisition software for DST. Resource constraints quickly developed causing a backlog of meter set-ups.

Full Scale Sample Deployment

NSTAR designed a total of thirteen (13) new samples for its three (3) territories. Installations began in May 2006 and will continue till the end of 2007.

NSTAR utilized traditional stratified random sampling techniques in the sample designs. These techniques included Dalenious-Hodges methodology for the calculation of strata breakpoints and Neyman Allocation methodology for the determination of the optimal number of sample points for each stratum.

A 10-20 % data loss factor was applied to the sample sizes to ensure that a 10% loss of data would not impact the validity of sample results. Meter Operations specifically requested this data loss factor to provide some buffer in the installation and data acquisition process. Since NSTAR did not have a good history of successful installations, a certainty stratum was not used in any of the designs. The primary assumption of a certainty stratum is that interval metering will be installed at these sites. Since the probability that some of the certainty sites may not be installed, NSTAR took a more conservative approach to its sample design methodology and decided to accept the higher sample size in lieu of a certainty stratum, ensuring that the samples accounted for the overall variability in the population.

Sample Installation Rules

Load Research set certain ground rules around the sample installations, since great care was required to minimize any sample bias due to the installation process and procedures. Since NSTAR had experienced significant sample bias in the past due to faulty installation procedures, the pilot did help to identify the areas where bias could result through NSTAR's installation processes and minimize the impact.

The Team determined that only remote interrogation technology would be used for the sample installations. If a primary site did not allow remote interrogation technology to be installed, an alternate site was identified. However, every effort was made to install the primary sites that were selected. Special attention was given to the reasons why sample points were rejected before installation to minimize bias caused by systematic reasons, for example, indoor sites versus outdoor sites. Load Research provided an alternate point only after all reasonable attempts to install at primary sites have been exhausted. Load Research had the final decision on rejections, removals, and replacements.

No load research samples will be used as the population for special energy efficiency programs and/or programs that could potentially influence energy usage patterns not representative of the target populations.

Measuring Sample Installation Success

To ensure that the team worked together on the installation goals, a shared performance measure was developed called the Sample Installation Rate. The target was to achieve a 95 % or greater sample installation rate. This target rate was set to guarantee that NSTAR could achieve the required accuracy levels for its statistical load analysis and minimize loss of data.

For each month Load Research calculated the rate for all samples being installed during the overall installation period. The rate assumed a six (6) month installation period for each sample. It distributed the number of sample points evenly over the 6 month period. For example, if the performance month is the first month of the six-month installation period for a sample, the sample installation rate would be calculated as follows:

# of sample points installed in a sample = 25
# of design sample points in a sample = 150

Sample Installation Rate=25/ (150 *(1/6)) = 100%

The sample installation rate measure was good in theory, yet in practice the measure did not provide the appropriate message to the Team because of project delays. These delays were caused by several factors including:

- The time span between the meter orders to delivery took much longer than planned. The original estimates from the vendors was six (6) weeks, while in actuality the delivery timeframes were more than ten (10) weeks.
- The meter set-ups in the data acquisition systems required more time than originally anticipated. When the installations went into full deployment, the data acquisition group had difficulty keeping up with the installation volume. Data Acquisition hired additional staff and implemented overtime.
- After the initial deployment of meters SmartSynch developed an improved antennae and firmware for their communication module which dramatically improved the communication performance of the meter and data acquisition system. At this time a decision was made to return all meter inventory to SmartSynch for retrofitting to the new firmware and antennae.
- The MV-90 system and SmartSynch TMS systems were upgraded in spring 2007. Data Acquisition resources were redirected to these efforts since the upgrades were problematic, causing a significant set-up backlog.

Realistically, the installation timeframes for each sample are closer to a year.

Load Research defined another way to measure sample installation success, a failure date for each sample. If a sample is not fully installed by the failure date, the sample would need to be redesigned. At this time there are only two samples that are being considered for redesign, due to the project delays. These redesigns may impact the delivered meter inventory that was ordered based on selected sample site meter forms.

Another useful measurement of installation success which helped to understand if Load Research was really receiving data were two reports on late meter reads. Load Research created a "35 to 45 days late read" report and a "Greater than 45 days late read" report. These reports by far have been the most useful, since it truly identifies if Load Research is receiving data. These reports were the impetus for a SWAT team. The IDM team was seeing a marked increase in the number of installations appearing on the reports, 221 out of 1028 installations, over 20 %.

Next Steps: SWAT Team

The IDM team established a SWAT team to address the 221 load research meters that have been installed, yet were not passing data to Load Research, or had passed data initially and were currently not pass data. The SWAT team put a halt to the installations. The first goal of the SWAT team was to identify if the issues were caused by technology. Fortunately, they were not. Of the meters that have been set-up correctly, data flows easily to Load Research. It was found that these problem meters had never been set-up correctly within our data acquisition systems. Most issues were due to:

- Significant backlog in set ups
- Incorrect transfer switches in the data acquisition systems
- Meters not defined to the correct groups
- Incorrect provisioning of the meters, and
- Individual set-up issues such as manual entry errors.

Table 1 provides a sample installation status as of the end of June. The table identifies the sample design sample sizes, how many sample meters have been installed, not installed, have not sent data to Load Research, are current in data transfers, are 35 to 45 days late in data transfers (Pre SWAT team and SWAT team), are greater than 45 days late in data transfers (Pre SWAT team and SWAT team), and the scheduled installation completion dates.

The SWAT team developed a just-in-time sample installation process to eliminate these set up issues and to enhance the set-ups for the remaining installations. In the past couple weeks, the Team has made progress in reducing the number of late reads, "34-35 days" late reads from 51 to 37 and "> 45 days" late reads from 170 to 122.

One of the meter managers used a famous quote to describe our recent predicament with the sample installations:

> "We have met the enemy and he is us."
> *Walt Kelly*

The quote received a good chuckle out of the Team that has worked so hard this past year to get these samples installed. The Team still has work ahead to improve the set-up process and to get the samples installed. No doubt, there will be other storms along the way. As a matter of fact, NSTAR just had a few hot days and the Team found that the modems turn off during very hot or very cold ambient temperatures, delaying data acquisition. The Team knows that the samples installations will be a success and the data will get to the right place, in the hands of Load Research. It just takes time, hard work, and teamwork.

Table 1
Sample Installation Status

	Design	# of Strata	Installed	Not Installed	No Data	Data Current	Pre-SWAT Data > 34 Days	SWAT Data > 34 Days	Pre-SWAT Data > 45 Days	SWAT Data > 45 Days	Install Date
BECO R1	220	4	220	0	0	183	6	4	40	33	√
BECO R2	82	2	82	0	0	75	4	3	3	4	√
BECO R3	161	4	160	1	0	108	9	9	45	43	√
BECO G1	200	5	77	123	65	0	0	12	0	0	Aug-07
BECO G2	160	4	0	160	0	0	0	0	0	0	Aug-07
CAMB R1	160	4	134	4	43	83	17	8	6	0	Jul-07
CAMB R2	81	2	81	0	0	75	9	0	1	6	√
CAMB R3	165	3	164	1	9	119	0	1	74	35	Jul-07
CAMB G1	198	5	1	197	0	0	1	0	0	1	Aug-07
COMM R1	176	4	109	66	31	78	5	0	1	0	Dec-07
COMM R2	88	2	0	88	0	0	0	0	0	0	Dec-07
COMM R3	165	3	0	165	0	0	0	0	0	0	Dec-07
COMM G1	210	5	0	210	0	0	0	0	0	0	Dec-07
	2066		1028	1015	148	721	51	37	170	122	