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AMI Data Management Guidebook

First Edition

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AMI Data Management Guidebook

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This is an EPRI Technical Update report. A Technical Update report is intended as an informal report of continuing research, a meeting, or a topical study. It is not a final EPRI technical report.

NOTE

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Principal Investigator
E. Beroset

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Abstract

This report describes the management of AMI data after it has been received by the Head End system. Based on a series of meetings with industry experts, this guidebook describes aspects of AMI data management including use cases, system architecture, data characteristics and data policies.

Keywords
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Product Type: Technical Update

Product Title: AMI Data Management Guidebook: First Edition

PRIMARY AUDIENCE: Utility personnel working with AMI data

SECONDARY AUDIENCE: System architects, policy writers, data scientists

KEY RESEARCH QUESTION

Utilities are gathering and storing ever increasing amounts of AMI data. What should happen to the data after it arrives at the AMI system Head End? This research examines the practices, architecture, data and policies currently in use in the industry.

RESEARCH OVERVIEW

Through a series of weekly conference calls, data for this report was gathered from utility personnel working with AMI data.

KEY FINDINGS

- There are multiple ways to connect systems to the AMI Head End (Section 3)
- Meter data can be characterized by type and purpose (Appendix A)
- A relatively short list of possible use case for AMI data covers many relevant issues (Section 1)
- A sample “code of conduct” form for employees seeking access to AMI data is included (Section 2)
- Data privacy, data retention, and data destruction are all important factors to consider when devising an AMI data policy (Section 4)

WHY THIS MATTERS

Members using this report will gain insight into what their peers are doing with data access and AMI system architecture. Carefully considering the questions raised in the policy section will help inform the creation of sound and robust data access policies.

HOW TO APPLY RESULTS

Selecting use cases from among the ones listed may help both experienced and inexperienced utility personnel better understand the overall issue of AMI data management. Examining the data architectures used by other utilities and studying data management policy questions will aid in creating a holistic view of AMI data management.

LEARNING AND ENGAGEMENT OPPORTUNITIES

- Ongoing work in the Advanced Metering Systems (161F) project set will expand on both use cases and the type and qualities of AMI data.

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PROGRAM: PS161F Advanced Metering Systems (106158)

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Section 1: Example Use Cases

Context

EPRI's Advanced Metering Systems Research (161F) has created a series of guidebooks for best practices over the past several years on a range of topics relevant to the operation of Advanced Metering Infrastructure (AMI) systems. This document is the latest in that series and covers the topic of AMI Data Management.

This report catalogs current practices for handling, storing, accessing and interfacing AMI data after it has arrived at the head end system. The scope includes aspects of AMI data management including Head End System (HES), Meter Data Management System (MDMS), archival of data and the means to ensure secure access to authorized personnel within the utility. It will also address such questions as "Who within the utility should have access to the data?", "How, technically, should access to MDMS data be provided?", "Should external access be restricted to the MDMS only or should it allow access to the HES?" and "What processes should govern the destruction of data at the end of its useful lifetime?"

Example Use Cases

This section does not represent an attempt to describe all use cases; rather the goal is to choose a few for illustration and describe in detail how the use case, system architecture, security provisions and the size and nature of the data all interact. The text of most of the following descriptions are copied verbatim from EPRI's library of AMI use cases. [1] It should be understood that these use case descriptions each describe just one way to accomplish the use case's goal. Alternative mechanisms often exist and may, depending on utility needs and equipment capability, be more appropriate to a particular use. These examples are meant to be illustrative rather than prescriptive.

Monthly Billing

This use case addresses the four-hour Bulk Meter Readings message collected by the AMI Head-End System and the Scheduled Bulk Meter Readings that are exported to the Meter Data Management system (MDM) every 24 hours. This also covers the distribution of those reads from the MDM and AMI Head-End systems to the operational data store (ODS) and customer information system (CIS) systems.

The Meter Metrology Board (in the Smart Meter) continuously records the meters' electrical usage data including 15-minute interval data blocks. Every four hours the Meter Metrology Board sends the Bulk Meter Read Data (meter readings and 15-minute interval data for that four-hour time block) to the Network Interface Card (NIC) (in the Smart Meter). The NIC sends the meter data through the AMI Network to the AMI Head-End. The AMI Head-End sends batches of Bulk Meter Read Data to MDM where validation, estimation and editing (VEE) are completed. The MDM will also perform estimation for any missing meters. The MDM will then send the bulk meter reads (typically for a 24-hour period) to CIS and ODS. The ODS will then send the bulk reads to the Customer Web Portal.

Outage Reporting

This use case addresses the Outage Notification message generated by the Smart Meter and how this message gets generated into a trouble ticket.

Many AMI systems offer endpoints with a "last gasp" message transmission capability to tell the utility that the endpoints have lost power. This last-gasp transmission serves as a surrogate for the customer's call. AMI systems using these "last gasp" capabilities work well in helping the Outage Management System (OMS) and dispatcher understand and efficiently respond to widespread outage conditions.

This use case is unique as it is initiated at the NIC when it detects are zero voltage event lasting more than a programmed period of time. The NIC will issue a last-gasp message that flows back to the enterprise without any request from an enterprise system. The Last-Gasp Message is routed through the AMI Network to the AMI Head-End. The AMI Head-End sends the message to the ODS and the Outage Filter. The Outage Filter sorts the message(s) and sends it to the Trouble Ticket System (TTS). TTS sends the message to the OMS and the ODS. The OMS system updates the outage ticket and sends the update to TTS and ODS.

Outage Verification

This use case addresses the messages exchanged between Outage Management System (OMS) and AMI Head-End to accomplish an OMS Poll of a specific Smart Meter. This OMS Poll is a unicast request initiated manually. This is also used to verify outage restoration.

The OMS issues an OMS Ping Unicast Request to the AMI Head-End. The OMS Ping Unicast Request travels from the AMI Head-End, through the AMI Network to the NIC (part of the Smart Meter). The NIC transmits the OMS Ping Request to the Meter Metrology Board (part of the Smart Meter) where the voltage is actually read and returns the value to the NIC. The NIC sends the meter reading back up through the AMI Network to the AMI Head-End. The AMI Head-End sends the meter reading to the OMS.

On-Demand Read

The "On-Demand Read" (also known as an “On-Request Read”) allows utility staff to initiate a specific request to a meter to provide its data immediately. The normal behavior of the meter may only transmit data to the AMI headend occasionally, such as once per day, so that the most recent information is only available in the meter. Under certain circumstances, it may be desirable to have up-to-the-moment information.

The On-Request Read is a time sensitive function because human actors, including utility staff and customers, are waiting on the response. The data provided in an On-Request Read may vary depending on the billing rate structure, meter configuration, system capabilities and the needs of the requesting entity. In some cases, a single system may support multiple On-Request Read types.

Meter Firmware Upgrade

This use case describes how the Smart Meter’s firmware can be upgraded remotely via the AMI Network. Once an upgrade for the meter metrology firmware is made available, all meters within the AMI network can be upgraded automatically through the AMI network. The Metering Department personnel will trigger and supervise this process as executed via the AMI Head-End to the in-scope Smart Meters. Essentially a proprietary functionality offered by the AMI vendor, the meter firmware upgrade process is self-managing and happens over several days. Once a meter has received the upgrade file and applied the new firmware to its Metrology Board, the confirmation of the upgrade process comes back thru the AMI Head-End via the Network and is stored in Meter Data Management (MDM).

Communications Firmware Upgrade

This use case describes how the Network Interface Card’s (NIC) firmware can be upgraded remotely via the AMI Network. It is very similar to the Meter Firmware Upgrade except that because the metrology is not altered, some jurisdictions may allow this kind of upgrade but restrict Meter Firmware Upgrades. [2]

Once an upgrade for the NIC firmware is made available, all or a subset of devices within the AMI network can be upgraded automatically through the AMI network. The Metering Department personnel will trigger and supervise this process as executed via the AMI Head-End to the in-scope devices. Essentially a proprietary functionality offered by the NIC vendor, the NIC firmware upgrade process is self-managing and happens over several days. Once a NIC has received the upgrade file and applied the new firmware to itself, the confirmation of the upgrade process comes back thru the AMI Head-End via the Network and is stored in Meter Data Management (MDM).

Meter Configuration Update

This is like the Meter Firmware Upgrade, but rather than distributing a new firmware image, only the configuration of the meter is changed. This may include changing profile data intervals or potentially changing the configuration of billing as when a customer elects to change from a flat kWh rate to a Time-of-Use (TOU) rate.

When a new meter configuration for the meter is made available, all selected meters within the AMI network can be upgraded automatically through the AMI network. The Metering Department personnel will trigger and supervise this process as executed via the AMI Head-End to the in-scope Smart Meters. Essentially a proprietary functionality offered by the AMI vendor, the meter reconfiguration process is self-managing and happens over several days. Once a meter has received and applied the new configuration to its Metrology Board, the confirmation of the reconfiguration process comes back thru the AMI Head-End via the Network and is stored in Meter Data Management (MDM).

Communications Configuration Update

This use case is to Communications Firmware Update as Meter Configuration Update is to Meter Firmware Upgrade. That is, rather than distributing a new firmware image, only the configuration of the communications card is changed. This kind of update typically involves communication parameters or settings but not meter functions.[1]

When a new communications configuration for the NIC is made available, all selected devices within the AMI network can be upgraded automatically through the AMI network. The Metering Department personnel will trigger and supervise this process as executed via the AMI Head-End to the in-scope devices. Essentially a proprietary functionality offered by the AMI vendor, the meter reconfiguration process is self-managing and happens over several days. Once a meter has received and applied the new configuration to its Metrology Board, the confirmation of the reconfiguration process comes back thru the AMI Head-End via the Network and is stored in Meter Data Management (MDM).

Power Quality Study

In this use case, deployed Smart Meters are used to perform a power quality study. Metering Department personnel identify both a measurement to be taken and the subset of meters on which this will be done. As an example, voltages on a set of feeders might be logged and subsequently analyzed to make sure that voltages remain within limits at all points in the system.

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[1] Note that because a NIC may be used for purposes other than metering, such as providing communications for street-light controls or distribution automation over the AMI network, not every device with a NIC is necessarily a meter. Such devices are out of scope for this Technical Update, but the update process is similar.

Because this is a superset of the Meter Configuration Update use case, those steps apply. After sufficient power quality data has been gathered and retrieved from the relevant meters, utility personnel can analyze the data and optionally, reconfigure the meters again to stop logging power quality data or to log some other quantities.

High Usage Alert

A High Usage Alert is a service offered to utility customers. If the customer has elected to receive such alerts and if the customer's energy usage trend suggest that the monthly bill will exceed the previous year's corresponding month by more than 30% (or some other threshold value), an alert will be sent via the customer's preferred mode, such as via email or text message.

The Operational Data Store (ODS) is periodically updated by the AMI system with current readings from each meter (see the Monthly Billing use case for details on this mechanism.) The ODS will compare the extrapolated usage to the previous year's usage and send the appropriate communication via email or text message.

End Customer Usage Data Access

Utility's customers have access to a web portal to view usage information. This portal has its own database that is updated via an extract from the Operational Data Store (ODS). On a regular basis, a batch file is extracted from the Operational Data Store (ODS) and inserted into the database that supports the Customer Web Portal.

Communications Route Mapping

This use case involves the mapping of the communications route(s) from deployed meters to the Head-End System (HES). This can be useful to help pinpoint localized Radio Frequency (RF) communications problems, as with interference or signal blocking due to new construction, or to identify and locate misplaced meters; that is, meters for which the system's stored meter location information and actual location differ as might happen if the original meter installation had been incorrectly entered into the system.

During the regular operation of the Network, communications route and often other communications metrics are gathered and stored by the Head-End System (HES).

This information can be analyzed by Metering Department personnel either with or without overlaying Geographic Information System (GIS) data.

Section 2: Typical AMI Data

This section will describe the kinds of data that comes into a typical AMI Head End System and give some general information about how frequently such data is updated and approximate dimensions (in bytes).

The following data table represents the data within a typical AMI meter, expressed as an ANSI C12.19 table reference. [3] See section 4 for details of the contents of these tables. Although not included within this technical update, a similar mapping could be done for DLMS/COSEM objects as well. [4]

Within the table, data is classified into four types: *fixed*, *configuration*, *logged*, and *ephemeral*. *Fixed* indicates data, such as serial number, that is usually not changed during the meter's operation. *Configuration* is data, such as the number and types of measurements to store, that is changed, but infrequently, if at all. Both fixed and configuration data is likely to be cached at the head end and only read once or not at all from the device. *Logged* data is data such as kWh usage or outage count that is stored in the meter for later retrieval. Finally, ephemeral includes data such as the time of day clock or instantaneous voltage reading that is available but not stored in the meter.

Table 2-1
Typical Residential Meter Data Summary

Table Number	Table Name	Table Type	Table Bytes
0	General Configuration Table	fixed	88
1	General Manufacturer Identification Table	fixed	32
2	Device Nameplate Table	fixed	54
3	End Device Mode Status Table	logged	41
4	Pending Status Table	logged	94
5	Device Identification Table	configuration	20
6	Utility Information Table	fixed	232
10	Data Source Dimension Limits Table	fixed	15
11	Actual Data Sources Limiting Table	configuration	15
12	Units of Measure Entry Table	fixed	52

Table 2-1 (continued)
Typical Residential Meter Data Summary

Table Number	Table Name	Table Type	Table Bytes
13	Demand Control Table	configuration	12
15	Constants Table	configuration	256
16	Source Definition Table	configuration	104
20	Register Dimension Limits Table	fixed	24
21	Actual Register Limiting Table	configuration	24
22	Data Selection Table	configuration	103
23	Current Register Data Table	logged	496
25	Previous Demand Reset Data Table	logged	81
30	Display Dimension Limits Table	fixed	17
31	Actual Display Limiting Table	configuration	17
32	Display Source Table	configuration	256
33	Primary Display List Table	configuration	137
40	Security Dimension Limits Table	fixed	6
41	Actual Security Limiting Table	configuration	6
42	Security Table	configuration	84
43	Default Access Control Table	configuration	8
44	Access Control Table	configuration	128
45	Key Table	configuration	80
50	Time and TOU Dimension Limits Table	fixed	9
51	Actual Time and TOU Limiting Table	configuration	9
52	Clock Table	ephemeral	13
53	Time Offset Table	configuration	11
54	Calendar Table	configuration	18018
55	Clock State Table	ephemeral	14
56	Time Remaining Table	ephemeral	3
70	Log Dimension Limits Table	fixed	26
71	Actual Log Limiting Table	configuration	26
72	Events Identification Table	configuration	16
75	Event Log Control Table	configuration	48
76	Event Log Data Table	logged	10098
79	Event Counters Table	logged	4

Section 3: AMI System Characteristics

Data that arrives at an AMI head end system (HES) is typically routed to multiple other systems serving multiple kinds of purposes. One such diagram, courtesy of Duke Energy, is shown in Figure 3-1below.

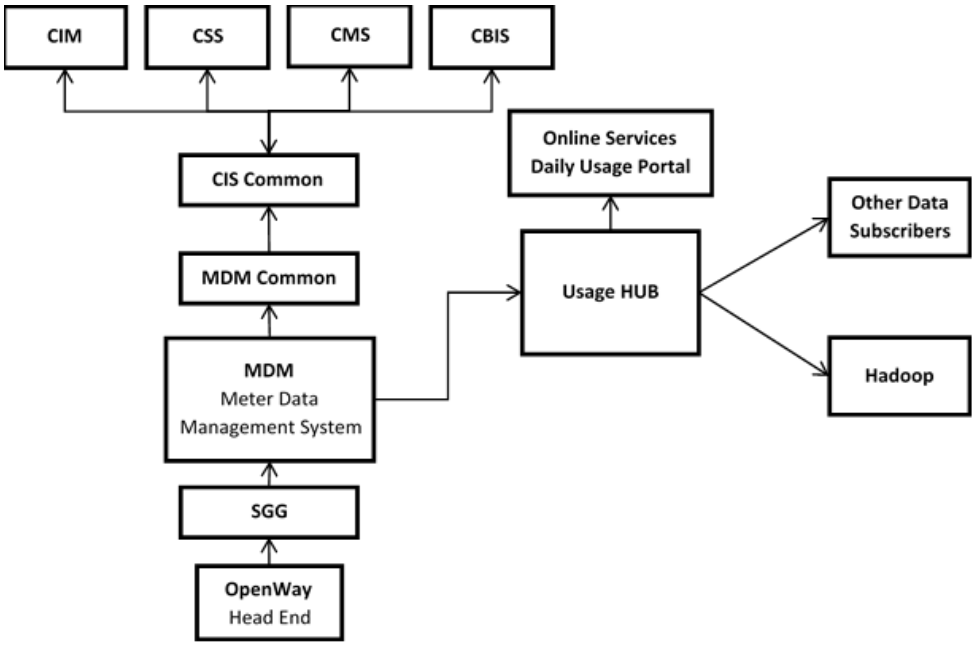

Figure 3-1
Example AMI System Configuration (Duke Energy)

Another example, courtesy of Southern Company, is shown in Figure 3-2.

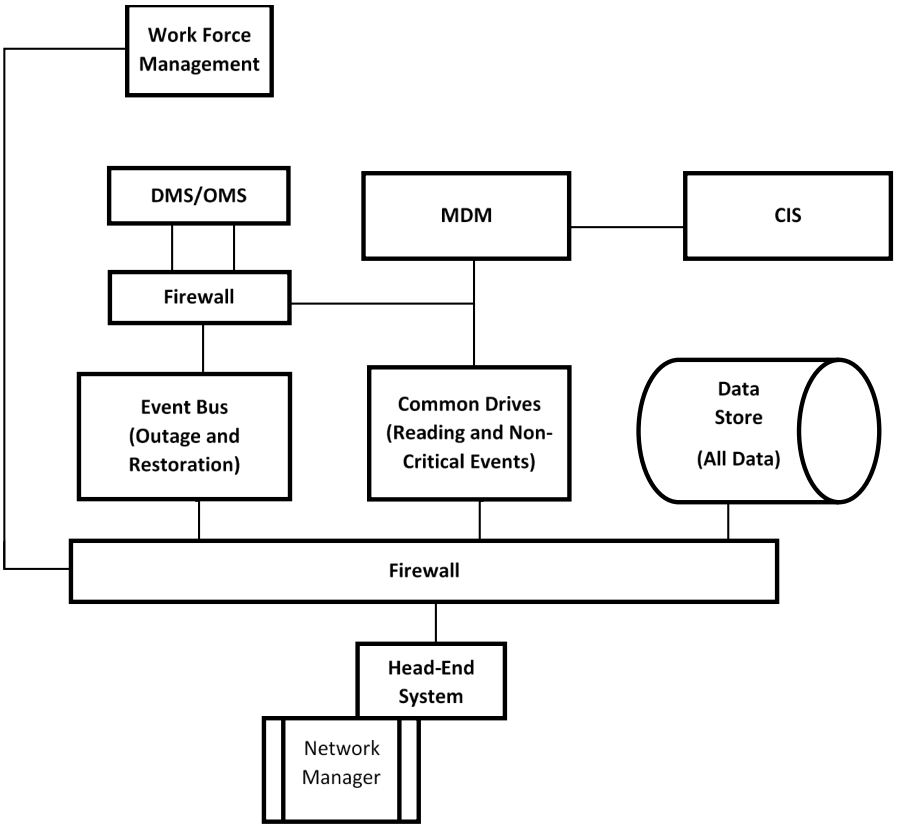

Figure 3-2
Example AMI System Configuration (Southern Company)

A third illustration of an example AMI system configuration, contributed by Hydro One, is shown in below.

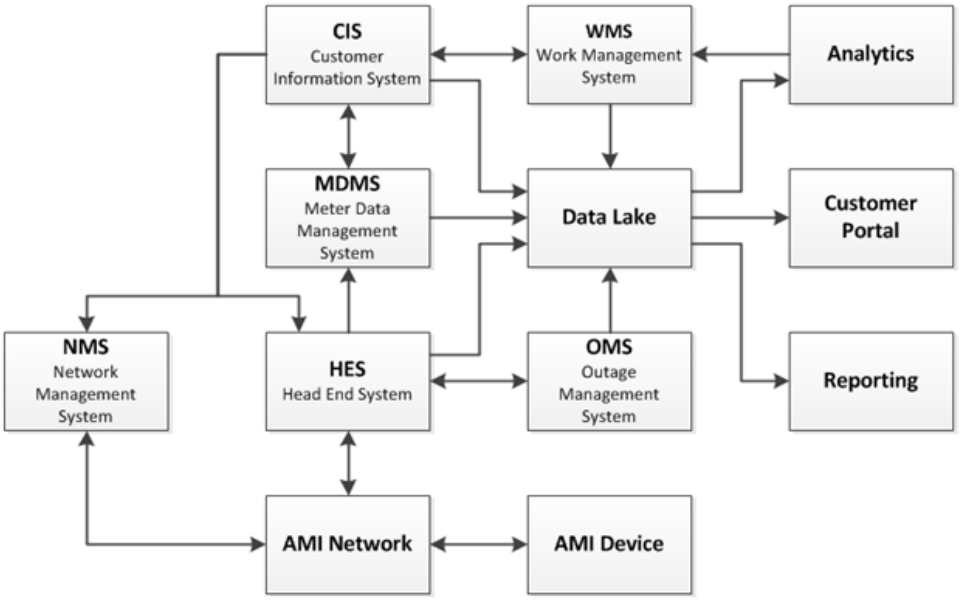

Figure 3-3
Example AMI System Configuration (Hydro One)

Table 3-1
Data Categories, Sources, Uses and Systems-of-record (Hydro One)

Category	Data Type	Description	Customer	Utility	Vendor	AMI Device	AMI Network	NMS	HES	MDMS	CIS	WMS	OMS
Metrology	Electricity Measurements	Interval and index readings measured by the meter (AMI Device) for Energy (kWh), Voltage (V), Current (I), Power (kW, kVA, kVAr), Frequency (Hz). Instantaneous, average, max, min readings. Readings by phase.				S			U	R			
AMI	AMI Device Events	Events generated by the AMI device (meter or network) e.g. tamper, clock sync, etc.				S	S	U	U	R			
AMI	AMI Device Attributes	Variable attributes of the AMI Device. Firmware version, configuration settings, communication path (parent node, router). Note: firmware, configuration, and network management functions may reside in the HES and/or NMS, depending on vendor			S	S	S	U	R				
AMI	RTPO/R	Real-time Power Outage/Restoration alarm				S	S		U				R
AMI	Network Attributes	RF signal strength, parent node in the network, routing path				S	S	R					
AMI	Network Reliability	Communication network performance, up-time, down-time						S/R					
Customer	Customer Data	Customer account data e.g. Name, address, contact info	S								R	U	U
Asset	Device ID	Serial number of the AMI Device (meter or network)			S	U	U	U	U	U	R	U	U
Asset	Meter Multiplier	Internal metrology/display multiplier			S	U				U	R		
Asset	Asset Properties	Properties of the physical asset. Operating range for voltage, current, frequency. Form factor, number of phases, manufacturer, model			S						R		
Asset	Instrument Transformer	External Current and Voltage transformer type, winding ratio			S					U	R		
Location	Service Point	Service location details, Service Point ID, premise type		S					U	U	R	U	U
Location	GPS	Latitude, Longitude		S		S	S	U	U		R	U	U

Table key: U = User of data, S = Source of data, R = system of Record

Section 4: Data and Policy

Data Characteristics

The data that comes from an AMI system can be characterized in many ways. Such characterizations can be useful for thinking about both the nature of the data itself and also the policy implications. Three ways to characterize the data include the frequency, the content, and the age. The following sections describe these data characteristics in a little more detail.

Data frequency

Data frequency, in this context refers not to the nominal 50Hz or 60Hz system frequency but to the frequency with which the data is updated within the end device. Some data items, perhaps such as daily meter self-read data is updated daily. Other data, such as voltage readings or 15-minute profile data from meters may be stored on a more frequent basis such as every 15 minutes. Configuration data is typically not read or written on a regular basis but can be pushed to the devices to alter the operation of the meters and other connected devices. Configuration data is typically much less often updated than meter data. Still other data is permanent, such as the serial number of a particular meter or device, or possibly nameplate data for meters or other connected devices. Finally, some data is ephemeral and is not stored within the meter, but is read as need on an ad hoc basis. Instantaneous on-demand per-phase voltage and current levels is an example of ephemeral data.

Data content

At the most basic categorization, some of the data is meter-centric (such as meter nameplate data, configuration data, energy and demand readings), while some is communications network-centric (such as current network topology, access-point to device mapping, network statistics and currently assigned IP address). There is also the possibility that devices other than meters are connected to the network, and these devices, too, will have device-specific data.

Data age

The age of the data is contrasted with the frequency of the data in that the update frequency refers to the update of the data within the device, but the age of the data refers to the age within the head-end and other associated systems. For example, a daily read might be stored daily within the meter, but could be more

than 24 hours hold if the current reading has not been retrieved or only one minute old if it has just been obtained from the device. This measure is intended to convey a sense of the "staleness" of the data which is often useful metadata for applications using meter data.

Policy considerations

Data access

One primary question about data access is the answer to the question "Who has access?" For some utilities, the answer to this question is "anyone within the utility who has a legitimate use for the data not in conflict with any other policies."

To assure that only authorized personnel have access to the data, it is often useful to create and maintain an internal "Acceptable Use Policy." If third parties are also given access to some data, an even more formal process is likely to be needed, including both business and legal review. In either case, controls and record-keeping are often employed.

One example of such a control, contributed by Southern Company, is the code of conduct form shown below:

> Southern Company Smart Energy Advanced Metering Infrastructure Data Store
>
> Code of Conduct
>
> Purpose:
>
> The purpose of the Code of Conduct is to ensure compliance with Southern Company policies and procedures and to protect the Company, its employees, and customers.
>
> Southern Style is our model for corporate and professional behavior. The Southern Company Code of Ethics and the Corporate Policies and Guidelines define acceptable behaviors. Behaviors performing daily responsibilities are further governed by Southern Company and its affiliates' Customer Service Standards. This Code of Conduct is intended as a supplement to the above mentioned policies, guidelines, and standards.
>
> By following the guidelines provided in Southern Style, the Southern Company Code of Ethics, the Corporate Policies and Guidelines, and this Code of Conduct, we ensure our compliance with legal and regulatory controls as well as the fair and consistent treatment of our customers.
>
> Employee Responsibility:
>
> Employees with access to customer account data, corporate proprietary data and/or confidential information in any application/database, including but not limited to, personally identifiable information (Personally Identifiable

Information (PII) – social security numbers, banking numbers, etc.), meter billing data, accuracy or rate adjustments and/or confidential customer information located in the Customer Information System (CIS or CSS), MDM Systems, AMI Network and Systems, Dashboards, Query Server, Automated Exceptions Database (AED) or other systems and field devices/software that store/access confidential customer information are required to sign and comply with this Code of Conduct.

Confidential Information:

I will use information that I have access to solely for the business purpose for which it was developed or given and not for personal gain. This includes, but is not limited to, information about the company, its customers, employees, vendors, and partners. I agree to maintain the confidentiality and security of information about Southern Company's customers and operations of its systems in accordance with company policies. Intentional access of data with direct database access that you are not approved is not permitted. No confidential and/or customer information, may to be released to a third party in any form without the appropriate management approvals and signatures on a non-disclosure agreement (NDA).

Examples of Prohibited Behavior:

- Providing customer or confidential/proprietary information to any individual, organization or company that is not authorized to access or receive that information by Southern Company or its affiliates.

Examples of Acceptable Behavior:

- Accessing customer information to assist a customer as long as it is for business purposes and the responsibility is within my job responsibilities.

Conflict of Interest:

- I will avoid conflicts or the appearance of conflicts between personal interests and the performance of my job duties.
- I will not access or ask another employee to access confidential customer data or perform any manipulation of data on my personal account(s).
- I will use available tools such as the Voice Response Unit (VRU) or operating company web site to access or process financial transactions. If these tools cannot be accessed, I will obtain approval from my supervisor or appropriate management to obtain access to or process an internal financial transaction on my personal account(s).

Conflict of Interest:

Examples of Prohibited Behavior:

- Modify code or any financial/confidential data that could cause a misrepresentation of account or company financial/confidential information
- Process a transaction on my personal account(s)
- Change database or file information that would misrepresent customer account or company financial/confidential data

Financial Integrity:

- I will not manipulate data in any way that would omit, conceal, or falsify financial records of any customer or the company, including and without limitation any employee, family member or friend.

Data Retention:

- I will adhere to the current data retention policy of my department for any data extracted from the data store. If I do not know the current data retention policy of my department then I will follow the current policy of the Data Store. The policy is all data must be deleted three years after the earliest extracted date of the data. Example: Data extracted from January 1st, 2013 to May 31, 2014. All data must be deleted, by January 1st, 2016.

Duty to Act:

I have a clear legal mandate to act ethically on the Southern Company's behalf and am obligated to report promptly to management any activities that may be in violation of this Code of Conduct, other company policies, or any applicable laws or regulations.

I understand and agree that the examples given in this Code of Conduct are not intended to be inclusive of every possible scenario but are given as examples only.

I acknowledge that I have read, understand, and agree to abide by this Code of Conduct. I understand that failure to comply with this Code of Conduct may result in disciplinary action, up to and including termination.

Employee Signature: _____

Date: _____

Supervisor Signature: _____

Date: _____

Data retention

One decision for how long to keep some types of data may already have been determined by regulators. If a utility regulator requires that billing dispute resolution data must be kept for some specific period years, this can sometimes be used as the determiner of the data retention period for all other AMI data as well. In Canada, for example, Measurement Canada specifies that the data corresponding to a particular meter is archived for the life of the meter plus one year after the seal expires. [5]

Another useful question to consider is what security measures should be in place to assure data integrity. That is, if stored data were altered or corrupted either accidentally or maliciously, what technical measures would allow for the detection or correction of the data?

Data tagging (metadata)

Data about data is called metadata. An example could be the GPS coordinates of a device or the time of day (measured at the head end) that a message arrived.

Some questions to consider when formulating policies include:

- Does metadata include usage policy? It may be useful for the usage policy to be bound with the data itself such that any recipient (human or machine) may be better able to comply.
- Are there policy-related metadata items that should be generated/maintained/disseminated with the data? Some examples of such metadata might be the version of policy under which the data was gathered, or a required data destruction date if known.

Data Quality

Data quality is an important aspect that should be understood and characterized before the data itself can be usefully employed. For many data quantities, such as energy and demand, there are relevant accuracy standards such as ANSI C12.20 or IEC 62053-22. [6] [7] Other quantities, such as voltage or temperature, may be available from devices within the system, but may have varying levels of data quality dependent on the design of originating instrument, the configuration parameters, and extrinsic factors such as whether the measurement is made directly or indirectly and whether associated equipment is working correctly (e.g. correct functioning of an instrument transformer or meter connection).

Among the questions to consider when devising policy about data quality are:

- What kind of data quality indicators associated with measured data are usually kept? (E.g. calibration data)
- How are these records linked to the associated data?

Privacy

A thoughtfully crafted policy must include privacy among the considerations for both data gathering and data use. The "Privacy by Design" framework has successfully been applied to meter data management in Ontario, Canada and may provide others with a useful resource in evaluating their own methods and policies, especially regarding privacy issues. [8]

Among the most fundamental questions to consider when crafting data privacy policies are:

- Who owns the data?
- How should it be kept from people who shouldn't have access to it?

Primary purpose

Primary purposes for the collection of AMI data are generally to create an accurate record of usage for billing, to provide for grid operation, and to provide services required by regulators.

The primary purpose for data gathering may have policy implications and may need to be explicitly stated. In some cases, it may, by either utility policy or regulatory authority, guide whether data may be used for secondary purposes or not.

Questions that may be useful to address in formulating policy on this topic are:

- What is the primary purpose for gathering this data?
- Are secondary uses allowed? If so, what are the implications? For example, in some cases, secondary uses may be allowed only if the data subjects are notified of and agree to the secondary use.

Data destruction

At the end of the data retention period, mentioned earlier, is the task of data destruction. By destroying, rather than merely discarding the data, the responsible entity takes steps to assure that the data is not disclosed to unauthorized personnel and that it is not used for disallowed purposes.

Questions to be considered include:

- When it is time for the data to be destroyed, how technically is this done? For example, if the data is stored on magnetic media, is degaussing the media sufficient? Is overwriting data stored on a hard drive sufficient? Is physical destruction of the media required?
- What exceptions should be built into the policy on data destruction? An example of such an exception might be if the records had been subpoenaed or if it is reasonably expected that they might be.

- Who does this data destruction? Identifying a specific person, by role, can be helpful in assuring that the relevant policies are actually carried out.
- Are there policies for notification before this occurs? There may be users, both inside and outside the utility, that have legitimate and compelling needs to retain certain data beyond the nominal destruction date. In such cases, notification of data destruction *after* the fact, is unlikely to be useful or appreciated.

Section 5: References

[1] EPRI, "AMI System Uses Repository," 5 November 2018. [Online]. Available: http://ami.epri.com/UseCaseSearch.aspx.

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[3] ANSI, "American National Standard for Utility Industry End Device Data Tables," NEMA, Rosslyn, VA, 2012.

[4] IEC, "Electricity metering data exchange - The DLMS/COSEM suite -- Part 5-3: DLMS/COSEM Application Layer," IEC , Geneva, 2017.

[5] Measurement Canada, "E-35—Policy on the retention of metering information and legally relevant interval data used in billing applications," 2 February 2017. [Online]. Available: https://www.ic.gc.ca/eic/site/mc-mc.nsf/eng/lm04789.html.

[6] ANSI, "ANSI C12.20-2010 Electricity meters - 0.2 and 0.5 accuracy classes," NEMA, 2010.

[7] IEC, "IEC 62053-22 Electricity metering equipment (a.c.) - Particular Requirements - Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)," IEC, Geneva, 2003.

[8] Information and Privacy Commissioner, Ontario, Canada, "Building Privacy into Ontario's Smart Meter Data Managment System: A Control Framework," Information and Privacy Commissioner, Ontario, Canada, Toronto, 2012.

[9] IEC, "IEC 62053-21 Electricity metering equipment (AC) - Particular requirements Part 21: static meters for active energy (classes 1 and 2)," IEC, Geneva, 2003.

Appendix A: Detailed Meter Data Enumeration

This is an example of the kinds data from a typical Residential Meter. Although it is expressed as ANSI C12.19 [3] data, a similar mapping could be made to DLMS/COSEM objects as well. [4]

Within the table, data is classified into four types: *fixed*, *configuration*, *logged*, and *ephemeral*. *Fixed* indicates data, such as serial number, that is usually not changed during the meter's operation. *Configuration* is data, such as the number and types of measurements to store, that is changed, but infrequently, if at all. Both fixed and configuration data is likely to be cached at the head end and only read once or not at all from the device. *Logged* data is data such as kWh usage or outage count that is stored in the meter for later retrieval. Finally, ephemeral includes data such as the time of day clock or instantaneous voltage reading that is available but not stored in the meter.

Table A-1
Typical Residential Meter Data Details

Type	Item name	Bytes	Count	Total bytes
fixed	ST-0.FORMAT_CONTROL_1	8	1	8
fixed	ST-0.FORMAT_CONTROL_2	8	1	8
fixed	ST-0.FORMAT_CONTROL_3	8	1	8
fixed	ST-0.DEVICE_CLASS	4	1	4
fixed	ST-0.NAMEPLATE_TYPE	1	1	1
fixed	ST-0.DEFAULT_SET_USED	1	1	1
fixed	ST-0.MAX_PROC_PARM_LENGTH	1	1	1
fixed	ST-0.MAX_RESP_DATA_LEN	1	1	1
fixed	ST-0.STD_VERSION_NO	1	1	1
fixed	ST-0.STD_REVISION_NO	1	1	1
fixed	ST-0.DIM_STD_TBLS_USED	1	1	1
fixed	ST-0.DIM_MFG_TBLS_USED	1	1	1

Table A-1 (continued)
Typical Residential Meter Data Details

Type	Item name	Bytes	Count	Total bytes
fixed	ST-0.DIM_STD_PROC_USED	1	1	1
fixed	ST-0.DIM_MFG_PROC_USED	1	1	1
fixed	ST-0.DIM_MFG_STATUS_USED	1	1	1
fixed	ST-0.NBR_PENDING	1	1	1
fixed	ST-0.STD_TBLS_USED	8	1	8
fixed	ST-0.MFG_TBLS_USED	8	1	8
fixed	ST-0.STD_PROC_USED	8	1	8
fixed	ST-0.MFG_PROC_USED	8	1	8
fixed	ST-0.STD_TBLS_WRITE	8	1	8
fixed	ST-0.MFG_TBLS_WRITE	8	1	8
fixed	ST-1.MANUFACTURER	4	1	4
fixed	ST-1.ED_MODEL	8	1	8
fixed	ST-1.HW_VERSION_NUMBER	1	1	1
fixed	ST-1.HW_REVISION_NUMBER	1	1	1
fixed	ST-1.FW_VERSION_NUMBER	1	1	1
fixed	ST-1.FW_REVISION_NUMBER	1	1	1
fixed	ST-1.MFG_SERIAL_NUMBER	16	1	16
fixed	ST-2.E_KH	6	1	6
fixed	ST-2.E_KT	6	1	6
fixed	ST-2.E_INPUT_SCALAR	1	1	1
fixed	ST-2.E_ED_CONFIG	5	1	5
fixed	ST-2.E_ELEMENTS	16	1	16
fixed	ST-2.E_VOLTS	8	1	8
fixed	ST-2.E_MAX_CLASS_AMPS	6	1	6
fixed	ST-2.E_TA	6	1	6
logged	ST-3.ED_MODE	1	1	1
logged	ST-3.ED_STD_STATUS1	16	1	16
logged	ST-3.ED_STD_STATUS2	16	1	16
logged	ST-3.ED_MFG_STATUS	8	1	8
logged	ST-4.STANDARD_PENDING	8	1	8
logged	ST-4.MANUFACT_PENDING	8	1	8
logged	ST-4.LAST_ACTIVATION_DATE_TIME	5	1	5

Table A-1 (continued)
Typical Residential Meter Data Details

Type	Item name	Bytes	Count	Total bytes
logged	ST-4.NBR_PENDING_ACTIVATION	1	1	1
logged	ST-4.PENDING_TABLES	9	8	72
configuration	ST-5.IDENTIFICATION	20	1	20
fixed	ST-6.OWNER_NAME	20	1	20
fixed	ST-6.UTILITY_DIV	20	1	20
fixed	ST-6.SERVICE_POINT_ID	20	1	20
fixed	ST-6.ELEC_ADDR	20	1	20
fixed	ST-6.DEVICE_ID	20	1	20
fixed	ST-6.UTIL_SER_NO	20	1	20
fixed	ST-6.CUSTOMER_ID	20	1	20
fixed	ST-6.COORDINATE_1	10	1	10
fixed	ST-6.COORDINATE_2	10	1	10
fixed	ST-6.COORDINATE_3	10	1	10
fixed	ST-6.TARIFF_ID	8	1	8
fixed	ST-6.EX1_SW_VENDOR	4	1	4
fixed	ST-6.EX1_SW_VERSION_NUMBER	1	1	1
fixed	ST-6.EX1_SW_REVISION_NUMBER	1	1	1
fixed	ST-6.EX2_SW_VENDOR	4	1	4
fixed	ST-6.EX2_SW_VERSION_NUMBER	1	1	1
fixed	ST-6.EX2_SW_REVISION_NUMBER	1	1	1
fixed	ST-6.PROGRAMMER_NAME	10	1	10
fixed	ST-6.MISC_ID	30	1	30
fixed	ST-6.FW_LOAD_DATE	2	1	2
fixed	ST-10.SOURCE_FLAGS	8	1	8
fixed	ST-10.NBR_UOM_ENTRIES	1	1	1
fixed	ST-10.NBR_DEMAND_CTRL_ENTRIES	1	1	1
fixed	ST-10.DATA_CTRL_LENGTH	1	1	1
fixed	ST-10.NBR_DATA_CTRL_ENTRIES	1	1	1
fixed	ST-10.NBR_CONSTANTS_ENTRIES	1	1	1
fixed	ST-10.CONSTANTS_SELECTOR	1	1	1
fixed	ST-10.NBR_SOURCES	1	1	1
configuration	ST-11.SOURCE_FLAGS	8	1	8
configuration	ST-11.NBR_UOM_ENTRIES	1	1	1
configuration	ST-11.NBR_DEMAND_CTRL_ENTRIES	1	1	1

Table A-1 (continued)
Typical Residential Meter Data Details

Type	Item name	Bytes	Count	Total bytes
configuration	ST-11.DATA_CTRL_LENGTH	1	1	1
configuration	ST-11.NBR_DATA_CTRL_ENTRIES	1	1	1
configuration	ST-11.NBR_CONSTANTS_ENTRIES	1	1	1
configuration	ST-11.CONSTANTS_SELECTOR	1	1	1
configuration	ST-11.NBR_SOURCES	1	1	1
fixed	ST-12.UOM_ENTRY	4	13	52
configuration	ST-13.RESET_EXCLUSION	1	1	1
configuration	ST-13.P_FAIL_RECOGNTN_TM	1	1	1
configuration	ST-13.P_FAIL_EXCLUSION	1	1	1
configuration	ST-13.COLD_LOAD_PICKUP	1	1	1
configuration	ST-13.INTERVAL_VALUE	2	4	8
configuration	ST-15.SELECTION	16	16	256
configuration	ST-16.SOURCES_LINK	8	13	104
fixed	ST-20.REG_FUNC1_FLAGS	8	1	8
fixed	ST-20.REG_FUNC2_FLAGS	8	1	8
fixed	ST-20.NBR_SELF_READS	1	1	1
fixed	ST-20.NBR_SUMMATIONS	1	1	1
fixed	ST-20.NBR_DEMANDS	1	1	1
fixed	ST-20.NBR_COIN_VALUES	1	1	1
fixed	ST-20.NBR_OCCUR	1	1	1
fixed	ST-20.NBR_TIERS	1	1	1
fixed	ST-20.NBR_PRESENT_DEMANDS	1	1	1
fixed	ST-20.NBR_PRESENT_VALUES	1	1	1
configuration	ST-21.REG_FUNC1_FLAGS	8	1	8
configuration	ST-21.REG_FUNC2_FLAGS	8	1	8
configuration	ST-21.NBR_SELF_READS	1	1	1
configuration	ST-21.NBR_SUMMATIONS	1	1	1
configuration	ST-21.NBR_DEMANDS	1	1	1
configuration	ST-21.NBR_COIN_VALUES	1	1	1
configuration	ST-21.NBR_OCCUR	1	1	1
configuration	ST-21.NBR_TIERS	1	1	1
configuration	ST-21.NBR_PRESENT_DEMANDS	1	1	1
configuration	ST-21.NBR_PRESENT_VALUES	1	1	1
configuration	ST-22.SUMMATION_SELECT	8	3	24

Table A-1 (continued)
Typical Residential Meter Data Details

Type	Item name	Bytes	Count	Total bytes
configuration	ST-22.DEMAND_SELECT	8	3	24
configuration	ST-22.MIN_OR_MAX_FLAGS	1	1	1
configuration	ST-22.COINCIDENT_SELECT	8	6	48
configuration	ST-22.COIN_DEMAND_ASSOC	1	6	6
logged	ST-23.NBR_DEMAND_RESETS	1	1	1
logged	ST-23.TOT_DATA_BLOCK	99	1	99
logged	ST-23.TIER_DATA_BLOCK	99	4	396
logged	ST-25.REGISTER_INFO	5	1	5
logged	ST-25.PREV_DEMAND_RESET_DATA	76	1	76
fixed	ST-30.DISPLAY_CTRL	8	1	8
fixed	ST-30.NBR_DISP_SOURCES	2	1	2
fixed	ST-30.WIDTH_DISP_SOURCES	1	1	1
fixed	ST-30.NBR_PRI_DISP_LIST_ITEMS	2	1	2
fixed	ST-30.NBR_PRI_DISP_LISTS	1	1	1
fixed	ST-30.NBR_SEC_DISP_LIST_ITEMS	2	1	2
fixed	ST-30.NBR_SEC_DISP_LISTS	1	1	1
configuration	ST-31.DISPLAY_CTRL	8	1	8
configuration	ST-31.NBR_DISP_SOURCES	2	1	2
configuration	ST-31.WIDTH_DISP_SOURCES	1	1	1
configuration	ST-31.NBR_PRI_DISP_LIST_ITEMS	2	1	2
configuration	ST-31.NBR_PRI_DISP_LISTS	1	1	1
configuration	ST-31.NBR_SEC_DISP_LIST_ITEMS	2	1	2
configuration	ST-31.NBR_SEC_DISP_LISTS	1	1	1
configuration	ST-32.DISPLAY_SOURCES	8	32	256
configuration	ST-33.PRI_DISP_LIST	3	3	9
configuration	ST-33.PRI_DISP_SOURCES	2	64	128
fixed	ST-40.NBR_PASSWORDS	1	1	1
fixed	ST-40.PASSWORD_LEN	1	1	1
fixed	ST-40.NBR_KEYS	1	1	1
fixed	ST-40.KEY_LEN	1	1	1
fixed	ST-40.NBR_PERM_USED	2	1	2
configuration	ST-41.NBR_PASSWORDS	1	1	1
configuration	ST-41.PASSWORD_LEN	1	1	1
configuration	ST-41.NBR_KEYS	1	1	1

Table A-1 (continued)
Typical Residential Meter Data Details

Type	Item name	Bytes	Count	Total bytes
configuration	ST-41.KEY_LEN	1	1	1
configuration	ST-41.NBR_PERM_USED	2	1	2
configuration	ST-42.SECURITY_ENTRIES	21	4	84
configuration	ST-43.TABLE_DEFAULT	4	1	4
configuration	ST-43.PROCEDURE_DEFAULT	4	1	4
configuration	ST-44.ACCESS_CONTROL	4	32	128
configuration	ST-45.KEY_ENTRIES	20	4	80
fixed	ST-50.TIME_FUNC_FLAG1	1	1	1
fixed	ST-50.TIME_FUNC_FLAG2	1	1	1
fixed	ST-50.CALENDAR_FUNC	1	1	1
fixed	ST-50.NBR_NON_RECURR_DATES	1	1	1
fixed	ST-50.NBR_RECURR_DATES	1	1	1
fixed	ST-50.NBR_TIER_SWITCHES	2	1	2
fixed	ST-50.CALENDAR_TBL_SIZE	2	1	2
configuration	ST-51.TIME_FUNC_FLAG1	1	1	1
configuration	ST-51.TIME_FUNC_FLAG2	1	1	1
configuration	ST-51.CALENDAR_FUNC	1	1	1
configuration	ST-51.NBR_NON_RECURR_DATES	1	1	1
configuration	ST-51.NBR_RECURR_DATES	1	1	1
configuration	ST-51.NBR_TIER_SWITCHES	2	1	2
configuration	ST-51.CALENDAR_TBL_SIZE	2	1	2
ephemeral	ST-52.CLOCK_CALENDAR	5	1	5
ephemeral	ST-52.TIME_DATE_QUAL	8	1	8
configuration	ST-53.DST_TIME_EFF	4	1	4
configuration	ST-53.DST_TIME_AMT	1	1	1
configuration	ST-53.TIME_ZONE_OFFSET	2	1	2
configuration	ST-53.STD_TIME_EFF	4	1	4
configuration	ST-54.ANCHOR_DATE	2	1	2
configuration	ST-54.NON_RECURR_DATES	3	32	96
configuration	ST-54.RECURR_DATES	3	16	48
configuration	ST-54.TIER_SWITCHES	3	32	96
configuration	ST-54.DAILY_SCHEDULE_ID_MATRIX	4	4444	17776
ephemeral	ST-55.CLOCK_CALENDAR	5	1	5
ephemeral	ST-55.TIME_DATE_QUAL	8	1	8

Table A-1 (continued)
Typical Residential Meter Data Details

Type	Item name	Bytes	Count	Total bytes
ephemeral	ST-55.STATUS	1	1	1
ephemeral	ST-56.TIER_TIME_REMAIN	2	1	2
ephemeral	ST-56.SELF_READ_DAYS_REMAIN	1	1	1
fixed	ST-70.LOG_FLAGS	8	1	8
fixed	ST-70.NBR_STD_EVENTS	1	1	1
fixed	ST-70.NBR_MFG_EVENTS	1	1	1
fixed	ST-70.HIST_DATA_LENGTH	1	1	1
fixed	ST-70.EVENT_DATA_LENGTH	1	1	1
fixed	ST-70.NBR_HISTORY_ENTRIES	2	1	2
fixed	ST-70.NBR_EVENT_ENTRIES	2	1	2
fixed	ST-70.EXT_LOG_FLAGS	8	1	8
fixed	ST-70.NBR_PROGRAM_TABLES	2	1	2
configuration	ST-71.LOG_FLAGS	8	1	8
configuration	ST-71.NBR_STD_EVENTS	1	1	1
configuration	ST-71.NBR_MFG_EVENTS	1	1	1
configuration	ST-71.HIST_DATA_LENGTH	1	1	1
configuration	ST-71.EVENT_DATA_LENGTH	1	1	1
configuration	ST-71.NBR_HISTORY_ENTRIES	2	1	2
configuration	ST-71.NBR_EVENT_ENTRIES	2	1	2
configuration	ST-71.EXT_LOG_FLAGS	8	1	8
configuration	ST-71.NBR_PROGRAM_TABLES	2	1	2
configuration	ST-72.STD_EVENTS_SUPPORTED	8	1	8
configuration	ST-72.MFG_EVENTS_SUPPORTED	8	1	8
configuration	ST-75.STD_EVENTS_MONITORED_FLAGS	8	1	8
configuration	ST-75.MFG_EVENTS_MONITORED_FLAGS	8	1	8
configuration	ST-75.STD_TBLS_MONITORED_FLAGS	8	1	8
configuration	ST-75.MFG_TBLS_MONITORED_FLAGS	8	1	8
configuration	ST-75.STD_PROC_MONITORED_FLAGS	8	1	8
configuration	ST-75.MFG_PROC_MONITORED_FLAGS	8	1	8
logged	ST-76.EVENT_FLAGS	8	1	8
logged	ST-76.NBR_VALID_ENTRIES	2	1	2
logged	ST-76.LAST_ENTRY_ELEMENT	2	1	2
logged	ST-76.LAST_ENTRY_SEQ_NBR	4	1	4
logged	ST-76.NBR_UNREAD_ENTRIES	2	1	2
logged	ST-76.ENTRIES	24	420	10080
logged	ST-79.CALIBRATION_COUNTER	2	1	2
logged	ST-79.PROGRAM_COUNTER	2	1	2

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