UCAIug Home Area Network System Requirements Specification

A Work Product of the OpenHAN Task Force formed by the SG Systems Working Group under the Open Smart Grid (OpenSG) Technical Committee of the UCA® International Users Group

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1. Introduction

In 2007, the UtilityAMI established the OpenHAN Task Force to develop guiding principles, use cases, and platform independent requirements for the utility Advanced Metering Infrastructure (AMI) projects incorporating Home Area Networks (HANs). The core development team included more than a dozen investor-owned North American utilities serving more than 28 million electric and gas customers in 17 states and provinces, as well as contributors from EnerNex Corporation, Tendril Networks, Mulligan Labs LLC, Itron, and Silver Spring Networks. The OpenHAN Task Force collaborated throughout 2007 and 2008 to draft the UtilityAMI 2008 Home Area Network System Requirements Specification and received ratification of v1.04 in August 2008 ("UtilityAMI 2008 HAN SRS").

Since that time, additional use cases and requirements have been identified. In response, the UCAIug OpenSG Technical Committee re-established the OpenHAN Task Force under the SG Systems Working Group in October 2009. The OpenHAN Task Force was directed to begin work on the next version of the HAN SRS document (UCAIug HAN SRS v2.0). The work to produce this document was a collaborative effort open to all interested parties. Participants included utilities, energy service providers, technology vendors, appliance manufacturers, software developers, and regulators.

The following conceptual diagram provides a high-level overview of the Smart Grid, its actors and their expected interactions. The red circle represents the area of focus for this HAN SRS document.

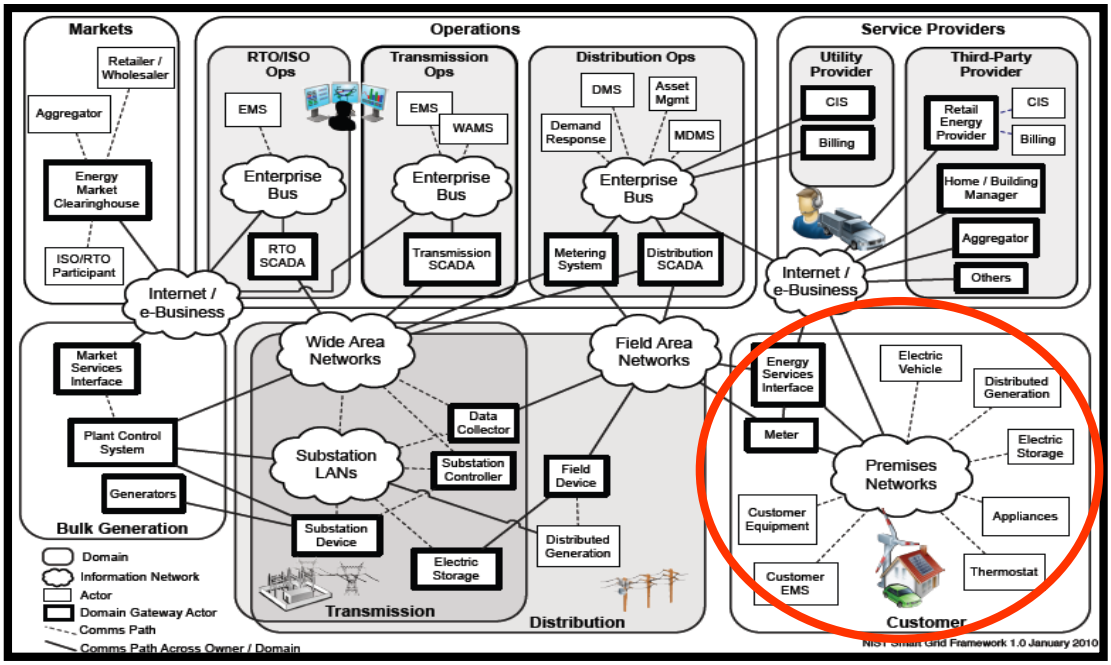

Figure 1 NIST Conceptual Reference Diagram for Smart Grid Information Networks[1]

[1] NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, page 35

This HAN SRS is organized as follows:

Section 1 – Introduction: outlines the purpose, scope, policy directives, and HAN security consideration that have shaped the HAN SRS. Also included is a comprehensive list of acronyms and definitions to help the reader interpret the HAN SRS.

Section 2 – Overall Description: describes the premises energy ecosystem, its guiding principles, and relevant architectural considerations.

Section 3 – System Requirements: provides context for and categorically lists all HAN System Requirements, then maps each to specific logical device types. Requirement categories for the HAN SRS are defined as follows:

- Application
- Communication
- Security
- Performance
- Operations, Maintenance, and Logistics

Section 4 – Appendices: offers supporting high-level system use cases and describes additional security considerations.

Although this document is a system requirements specification, it follows the IEEE 830-1998 Recommended Practice for Software Requirements Specifications[2] given the focus on Home Area Network (HAN) applications for utilities and consumers.

1.1 Purpose

One of the key outcomes of Smart Grid deployments is enabling informed participation by end-use consumers in retail and wholesale electricity markets. When consumers are given timely information about their electrical usage, this will empower them to manage their electricity usage, promote energy efficiency, and lower overall energy costs. Home Area Networks will play a role in achieving these goals by giving consumers more information than they have ever had before on how they use electricity and the cost of their usage. In addition, by using interoperable standards, utilities, device manufactures, vendors, and energy service providers can develop innovative and cost effective solutions and products which help consumers manage, optimize, and control their electricity usage.

To help achieve these goals and bring tangible Smart Grid benefits to Consumers, the OpenHAN Task Force undertook the development and subsequent revision of the HAN SRS. By providing common architecture, language, and requirements, the UCAIug HAN SRS 2.0 encourages a competitive market place and seeks to reduce costs, increase interoperability, and maximize solution longevity and maintainability.

[2] http://standards.ieee.org/reading/ieee/std_public/description/se/1233-1998_desc.html

Utilities and other Service Providers interested in establishing two-way communication with home area networks are encouraged to utilize and reference this document when evaluating and/or procuring smart grid systems that interact with HANs.

To ensure interoperability, testing and certification organizations should use this HAN SRS in their consideration of smart grid end-to-end testing involving HAN communication and device functionality. This comprehensive testing is a large and complex activity, involving many specifications, interfaces, and verifications, which are outside the scope of this HAN SRS. The HAN SRS is expected to lead to a set of discrete testable components as part of a larger smart grid system. The NIST Smart Grid Interoperability Panel Smart Grid Testing and Certification Committee (SGIP SGTCC) process and the UCAIug OpenSG Conformity Working Group have both been established to directly address these interoperability and compliance challenges.

The purpose of this HAN SRS is to:

- Define the system requirements for an open standard Home Area Network system
- Promote open standards based HANs that are interoperable
- Provide the vendor community with a common set of principles and requirements around which to build products
- Ensure reliable and sustainable HAN platforms
- Support various energy policies in a variety of states, provinces, and countries
- Empower consumers to manage their electricity consumption by giving them the information and control they need to make decisions on their energy use

The audience for this HAN SRS is:

- Utilities considering deploying AMI systems that interact with HANs
- Vendors that make AMI systems for Utilities that interact with HANs
- Vendors that make consumer products (e.g. programmable communicating thermostats, energy management systems, load control switches, in-home displays, smart appliances, Plug-in Electric Vehicles (PEV), distributed energy resources, etc.)
- Service Providers developing smart grid enabled programs for consumers (e.g. demand response, energy management, pre-pay, PEV programs, distributed energy resources, etc.)
- Policy makers looking to understand how Utility AMI deployments that interact with HANs benefit and impact consumers
- Industry alliances and standards organizations
- NIST Smart Grid Interoperability Panel (SGIP) activities (e.g. Smart Grid Architectural Committee (SGAC), Cyber Security Working Group (CSWG), Smart Grid Testing and Certification Committee (SGTCC), etc.)

As AMI and HAN systems continue to evolve, the UCAIug OpenHAN TF maintains an open door policy and encourages all interested parties (e.g. utilities, regulators, Service Providers, software vendors, original equipment manufacturers, etc.) to join the discussion.

1.2 Scope

This document includes guiding principles, use cases, system requirements, architectural drawings, and logical device mappings for platform-independent HAN Devices regardless of the ownership of the devices or the market in which they are deployed. This document provides platform-independent requirements and systems that Service Providers, Utilities, and vendors can use regardless of the technology they select.

The scope of this HAN SRS does not include, but has inherent implications for certain Utility Enterprise Systems (e.g. Utility AMI communications network, Meter Data Collection and Management Systems, etc.). It also does not apply to devices in the premises that are not part of the Home Area Network for energy management, as defined in this document (described in more detail in Section 2.2 – Architectural Considerations), but will have an impact on their usage and standardization. Some examples of these devices not covered in the scope of this specification are home automation, home health monitoring, and security system products.

While the residential consumer has the most to gain from the HAN SRS, the requirements in this SRS are applicable and may be used by commercial and industrial consumers as well.

As developed through guiding principles, use cases, and system requirements, this HAN SRS establishes the initial requirements and framework for the development of well managed and secure HAN communications systems. This is important and necessary given the increased risk to the electricity grid by the installation of in-premises HAN Devices (e.g. gateway, Energy Management System, etc.) that can engage in two-way communications using more than one communication media (e.g. Utility AMI network, internet, cell phone network, etc.) and may be commissioned to multiple Energy Services Interfaces (e.g. Utility ESI, third party ESI). As part of the Utilities' mandate to ensure a reliable electricity supply, security requirements have been included in this specification.

1.3 Acronyms and Abbreviations

This subsection provides a list of all acronyms and abbreviations used in this document.

AMI	Advanced Metering Infrastructure
CPP	Critical Peak Pricing
CSS	Customer Service System
DER	Distributed Energy Resources
EMS	Energy Management System
ESI	Energy Services Interface
ESU	Energy Supplying Unit
EUMD	End-Use Measurement Device
EVSE	Electric Vehicle Supply Equipment
FHDMC	Fixed Home Area Network Devices with Metering Capability

HAN	Home Area Network
HMI	Human / Machine Interface
IHD	In-Home Display
MHDMC	Mobile Home Area Network Devices with Metering Capability
PCT	Programmable Communicating Thermostat
PEV	Plug-in Electric Vehicle
SRS	System Requirements Specification
TOU	Time of Use

1.4 Definitions

This subsection provides the definitions of all terms used in this document.

Active Event	Refers to an event (e.g. demand response, price, emergency, etc.) that is underway.
Advanced Metering Infrastructure (AMI)	Advanced Metering Infrastructure refers to systems that measure, collect, and analyze energy usage from advanced devices (e.g. electricity meters, gas meters, and/or water meters), through various communication media on request (i.e. on-demand) or on a pre-defined schedule. This infrastructure includes hardware, software, communications, Customer Service Systems, meter data management software, metering system, network distribution business systems, Utility Energy Services Interface, etc. In some jurisdictions this may be called the Advanced Metering System (AMS).
Audit	A methodical examination or review of a condition or situation within a Home Area Network Device.
Capacity Billing Rates	Demand charges that apply to the peak rate of consumption (e.g. kWh demand, cubic feet per minute).
Charging Interval	The period of time that is bound by a start and stop of charging.
Commissioning	The process by which a HAN Device obtains access to a specific physical network and allows the device to be discovered on that network. The process may involve the exchange of information based on security credentials required to establish network coordination, assign device addresses, and to route packets. Admission to the network allows the HAN Device to communicate with peer devices on a network and receive Public Information from an ESI, but not information reserved for Registered devices.

Consumer	A person who consumes electricity, natural gas, or water and who has the greatest potential to conserve and manage the consumption of those utilities. The Consumer may participate in Service Provider programs (e.g. Demand Response, pricing, PEV programs, pre-pay, pricing, etc.). Consumers may also manage demand response events and daily usage by controlling HAN Devices manually or via other devices (e.g. EMS, etc.). Consumers may be distinct from the person or entity that pays for the consumption or enrolls in a Service Provider program.
Consumer Override	Refers to a consumer adjusting the functional behavior of a device to ignore or modify a Service Provider's Control Signal.
Control Signal	A structured message sent from an authorized party (e.g. Utility, Service Provider, EMS, Consumer) requesting operational state change of a HAN Device. This includes traditional direct load control commands (e.g. on/off, set duty cycle) and more advanced demand response commands where price or other data points may trigger a HAN Device to limit its energy consumption. HAN Devices will respond within the operation of their control systems and algorithms. This response may be based on consumer preferences, internal safety systems, preconfigured thresholds, time-based values, and/or adaptive algorithms that may be present in the HAN Device, EMS, and Service Provider solutions.
Critical Peak Pricing	Rates which typically charge a much higher price during a few hours per day on critical peak days. The number of critical peak days is usually capped for a calendar year and is linked to conditions such as system reliability concerns or very high supply prices.
Customer Representative	Person or intelligent system with which the Consumer interacts to work with a business (e.g. Utility, Service Provider, demand response aggregator, etc.).
Customer Service System	A system (e.g. system used by the call center) that provides Service Provider employees the ability to view Consumer-specific information (e.g. account information, billing, tariffs, programs, metering, interval usage, etc.). In some cases this system is also called a CIS (Customer Information System).
Demand Response	A temporary change in electricity consumption by a demand resource (e.g. PCT, smart appliance, pool pump, PEV, etc.) in response to a Control Signal which is issued. For purposes of this document, Demand Response does not include energy efficiency or permanent Load reduction.

Direct Load Control / remote load control	A Demand Response activity by which the Service Provider remotely shuts down, cycles, or reduces the load of an Enrolled HAN Device (e.g. air conditioner, water heater, smart appliances, etc.).
Distributed Energy Resources (DER)	Small, modular, energy generation and storage technologies that provide electric capacity or energy where it is needed.[3] May also be referred to as Distributed Generation.
Dynamic Energy Rate	Energy charges based upon market conditions which vary on an hourly or less than hourly basis. This may include real-time pricing or Dynamic Pricing.
Dynamic Pricing	Time-varying retail pricing of electricity that usually involves the capabilities of advanced meters and reflects fluctuations in grid conditions or the wholesale electricity prices on short notice, such as an hour or day in advance.[4]
Electric Vehicle Supply Equipment (EVSE)	The physical electrical cord and connectors that are specified by applicable SAE (Society of Automotive Engineers) standards that provide transfer of electric energy from the charging point to the PEV. The PEV connects to the electricity supply using an EVSE. The EVSE may contain HAN communications capability.
End-Use Measurement Device (EUMD)	The device that measures energy usage from an end-device (e.g. PEV, DER, appliance, etc.).
Energy Cost Application	Calculates energy consumption cost. The application may use information from multiple sources including: AMI meter(s), the AMI System, other application(s), other Home Area Network Device(s), Human Machine Interface(s), etc.
Energy Management System (EMS)	An application used for controlling multiple energy-controllable devices (e.g. pool pump, Programmable Communicating Thermostat, light switches, PEV charging, etc.). This application may reside within a HAN Device (e.g. Programmable Communicating Thermostat, In-Home Display, computer, cable set-top box, other computing device, etc.). This application may also control other devices or systems in the home providing integrated automated services for the Consumer.

[3] Definition of DER provided by the Department of Energy, http://www1.eere.energy.gov/femp/pdfs/31570.pdf

[4] U.S. Department of Energy Office of Electricity Delivery and Energy Reliability Smart Grid Investment Grant Program: DE-FOA-0000058, page 22

Energy Services Interface (ESI)	A secure interface to a premises communications network (i.e. HAN) which facilitates relevant energy applications (e.g. remote load control, demand response, monitoring and control of DER, in-premises display of energy usage, reading of energy and non-energy meters, PEV charging and roaming coordination, and integration with energy management systems, etc.), provides auditing / logging functions that record transactions to and from HAN Devices, and, often coordination functions that enable secure transactions between the HAN Devices Commissioned and Registered on its network and Enrolled in a Service Provider program. Note: There may be more than one ESI in a premises or more than one ESI in a HAN Device and each ESI defines an independent logical network.
Energy Supplying Unit (ESU)	An energy storage device (e.g. battery storage unit, electric vehicle battery) capable of providing power to a premises or the electric grid.
Enrollment	The process by which a Consumer enrolls a HAN Device in a Service Provider's program (e.g. demand response, energy management, pre-pay, PEV programs, distributed generation programs, pricing, messaging, etc.) and gives certain rights to the Service Provider to communicate with their HAN Device.
External Interface	Provides the HAN with access to a communication network outside of the premises. A Utility ESI, third-party ESIs, and gateways that connect to external communication networks (e.g. Utility AMI communication network, internet, cell phone network, etc.) are examples of external interfaces.
Fixed Home Area Network Devices with Metering Capability	A HAN Device which does not have mobility (i.e. DER, etc.) and includes measuring capability.
Home Area Network (HAN)	Within the scope of this SRS, a HAN is an energy related network used for communicating with devices within the premises. HANs do not necessarily require connectivity outside the premises, but may be connected to one or more external communication networks (e.g. Utility AMI, internet, cell phone network, etc.) using External Interfaces.
Home Area Network Device (HAN Device)	Within the scope of this specification, any device that communicates on the HAN.
HAN System	A collection of devices, actions, communication capabilities, and processes which enable a HAN to operate in a premises.
In-Home Display	The functionality of a HAN Device that receives and displays data. This functionality may reside in a separate display device or be integrated into another device with greater functionality, such as a PCT.

Installer	The entity who installs and at a minimum Commissions a Home Area Network Device in the Consumer's premises; Installer may be a 3rd party or the Consumer.
Labeling	Compliance, safety, and standards labeling.
Least Privilege	The concept of least privilege is to operate using the least set of privileges necessary to complete a given task. The ultimate goal is to eliminate damage that can occur from accidental errors or malicious intent.
Manufacturer	Defined broadly to include original equipment manufacturers, distributors, and value-added retailers and is accountable for ensuring proper out-of-box operation ready for, at a minimum, HAN Commissioning.
Measure	Determination of dimension, quantity, or capacity.
Meter	A device for which its primary function is to measure, record, and communicate usage and/or production of a commodity (e.g. electricity, water, gas, etc.) for an individual device or the premises.
Mobile Home Area Network Devices with Metering Capability (MHDMC)	A mobile end-use meter, downstream from the premises' electric meter (i.e. point of service meter), that is communicated to via the Home Area Network (e.g. PEV with an onboard EUMD).
MHDMC Owner	A Consumer who is the person or organization responsible for an MHDMC account.
Mode	A condition of the operational state (e.g. charging, discharging, power save) of a device.
Monitor	A device or arrangement for observing, detecting, or recording the operation of a machine or system.
Mutual Authentication	A process in which both entities in a communications link authenticate each other.
Network Management	The ability to diagnose system components, and to monitor and control the communication system.
Pending Event	Refers to an event (e.g. demand response, emergency, etc.) that is scheduled but has not yet happened.
Plug-in Electric Vehicle (PEV)	An electric powered vehicle that derives all or a portion of the energy required for propulsion from the electric grid. A PEV may be communications capable and become a member of a HAN.
Pool Pump Controller	The controller is a separate device that resides between the timer and the pool pump, has minimal intelligence, and sends and receives signals through the Home Area Network.
Pre-Commissioning	Custom configuration of a device done prior to HAN Device installation.
Premises	A geographical location (e.g. house, apartment, building, etc.) with which the meter is permanently associated.
Price Event	An event (e.g. demand response, emergency, etc.) based upon price.

Programmable Communicating Thermostat (PCT)	A thermostat that can communicate with the HAN.
Public Information	Public Information is one-way communication to Commissioned HAN Devices of information which is publicly available and of general interest to all or a large identifiable subset of consumers (e.g. energy conservation, environmental awareness, etc.).
Rate Tiers/Blocks	Energy charges which vary based on the accumulated consumption / production during a period of time.
Registration	The process by which a Commissioned HAN Device is authorized to communicate on a logical network. This involves the exchange of information based on security credentials with an ESI. The Registration process is required for the exchange of information based on security credentials between a Registered device and the ESI and among other devices Registered to that ESI.
Remote Upgrade	The ability to correct defects, enable new features and applications, change recording and reporting intervals, refresh security, and optimize network operation from an external location in a secure manner.
Security	Those measures that protect and defend information and information systems by assuring their confidentiality, integrity, access controls, availability, and accountability.
Service Point Location	Uniquely identifies the service delivery point.
Service Provider	An entity (e.g. Utility, retail electric provider, demand response aggregator, etc.) which provides energy services to Consumers.
Smart Appliance	A white good or household appliance, that has HAN communication capability and is capable of receiving signals from authorized parties (e.g. Utility, Service Provider, EMS, Consumer, etc.) and of adjusting its operational mode based on Consumer preferences (e.g. energy saving mode, delayed turn on/off).
State	A condition of the device (i.e. on/off).
Time of Use Rates	Energy charges which vary based upon a predetermined schedule of hours of the day and days of the week.
Utility	The electric service provider, which, at a minimum, is responsible for reading the electric meter, providing HAN access to the meter, and delivering energy to the consumer. This may be an integrated electric utility or a Transmission and Distribution utility.
Utility Enterprise System	Includes Advanced Metering Infrastructure system, Distributed Automation, and all other enabling technologies of the Utility operation.

Utility Energy Services Interface	An ESI, owned by the Utility, which enables secure interactions between HAN Devices Registered on its network and the Utility AMI. The Utility ESI functionality may reside in the AMI meter.

1.5 Other Considerations and References

The development of the UtilityAMI 2008 HAN SRS was motivated by legislative and regulatory policy directives and the proliferation of multiple technology standards and solutions for HANs. Regulatory policy directives played a key role in pushing Utilities to deploy AMI systems that provided consumers with more detailed energy consumption information and demand-reduction capabilities, including the California Public Utilities Commission Energy Action Plan and AMI Directives, the California Energy Commission J45 Reference Design for Programmable Communicating Thermostats (PCTs), the Public Utility Commission of Texas (PUCT) Advanced Metering rule, and the Michigan 21st Century Energy Plan. Another motivating factor driving the development of the UtilityAMI 2008 HAN SRS was to guide and direct the alliances who are responsible for developing HAN technology standards by providing a standard set of requirements. The UtilityAMI OpenHAN TF also leveraged the work of Electric Power Research Institute and the GridWise Architecture Council. These organizations provided a template and a foundation which was used to approach the development of the UtilityAMI 2008 HAN SRS.

Since the ratification of the UtilityAMI 2008 HAN SRS in August 2008, the national focus and attention on the Smart Grid, especially as it relates to enabling informed participation by consumers, has been intensified. The Energy Independence and Security Act of 2007 (EISA) made the development of a Smart Grid a national policy goal. EISA authorized DOE to solicit applications for the Smart Grid Investment Grant Program[5] (SGIG) and assigned the National Institute of Standards and Technology (NIST) the responsibility to coordinate the development of an interoperability framework between Smart Grid devices and systems that is “flexible, uniform and technology neutral”[6]. In February 2009, the U.S. Congress passed the American Recovery and Reinvestment Act (“ARRA”), which provided funding for DOE Smart Grid grants, other DOE incentives, and NIST for NIST to fulfill its EISA obligations.

In 2009 NIST began its work and by January 2010 NIST published the NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0. In this framework document, NIST recognized the UtilityAMI 2008 HAN SRS as a set of requirements for the Smart Grid data communications interface to in-premises devices. The UtilityAMI 2008 HAN SRS sets forth the requirements for secure communication between the Distribution and Customer domains and between the Service Provider and Customer domains as graphically depicted in Figure 2 of the NIST conceptual reference model.

[5] Section 1306 of the Energy Independence and Security Act of 2007, Public Law 110-140 (EISA)

[6] EISA Title Xiii, Section 1305

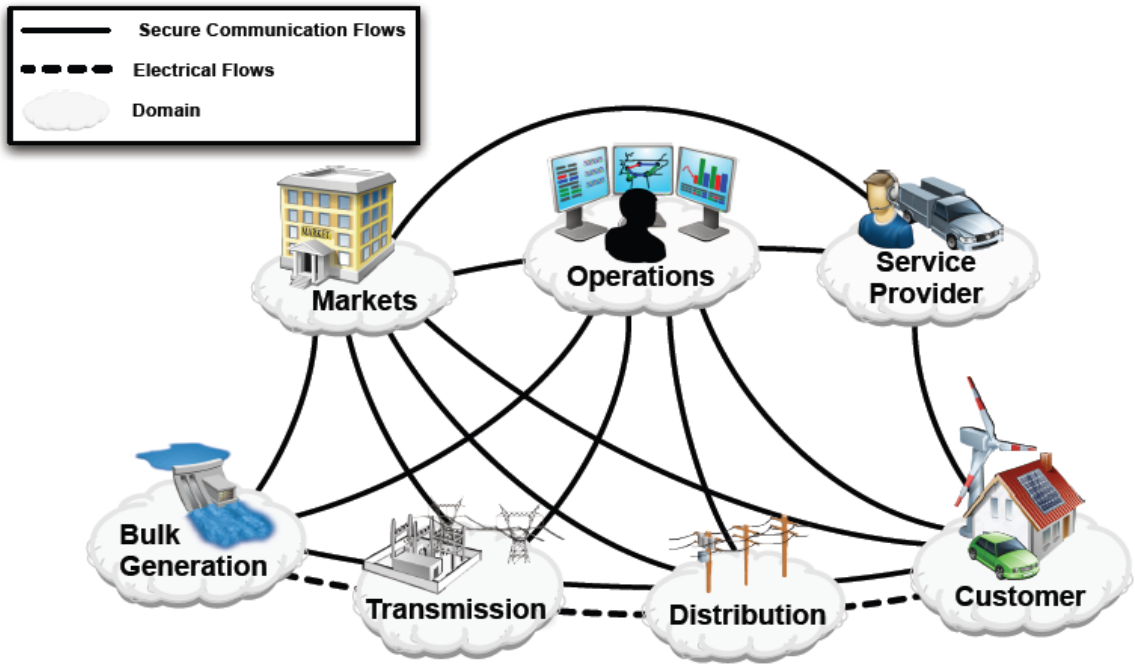

Figure 2 Interaction of actors in different Smart Grid Domains through Secure Communication Flows and Electrical Flows.[7]

In mid 2009, DOE issued the Smart Grid Investment Grant (SGIG) Program Funding Opportunity with specific goals including enabling informed participation by consumers in retail and wholesale electricity markets, enabling new products, services, and markets, and optimizing asset utilization and operating efficiency of the electric power system[8]. Reimbursement for project expenditures was contingent upon a project's compliance with relevant technical standards and the project's support for and compatibility with NIST's emerging smart grid framework for standards and protocols. DOE selected 100 projects to fund and many of those projects include providing energy usage information, dynamic pricing, demand response programs, smart appliances, and in-home displays. Use of the HAN SRS by these utilities and vendors will help them meet the DOE standards requirement, to further the development of Smart Grid functions, and bring the benefits of the Smart Grid to consumers.

The Department of Energy has also funded projects to demonstrate advanced Smart Grid technologies and integrated systems that will help build a smarter, more efficient, more resilient electrical grid. The Smart Grid Demonstration Grants (SGDGs) provided funding for thirty two demonstration projects, which include large-scale energy storage, smart meters, distribution and transmission system monitoring devices, and a range of other smart technologies. These projects are to act as models for deploying integrated Smart Grid systems on a broader scale.

[7] NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0., page 33

[8] U.S. Department of Energy Office of Electricity Delivery and Energy Reliability Smart Grid Investment Grant Program: DE-FOA-0000058, page 7

1.6 Security in the HAN Environment

The Smart Grid enables the two-way flow of information between devices in a Consumer's premises, which are connected to an energy Home Area Network (HAN), and a Service Provider's network. This type of communication is a new technology being introduced to the electric power grid through the deployment of Advanced Metering Infrastructure (AMI) systems, including smart meters, and HAN Devices. Since bi-directional communication with HAN Devices involves the flow of information through various networks, it is necessary to have proper security measures in place to reduce the risk of intrusion, eavesdropping, and transmitting unwanted content. In addition, each HAN Device, as a node on the network, has the potential to host, transmit, and receive unwanted content. Security in the HAN is a balance between securing the bi-directional communications, ensuring Consumer privacy while allowing access to the relevant stakeholders, and manufacturing cost effective HAN Devices. Emerging threat and attack vectors make cyber security an ongoing evolutionary process. Due to the ever-changing landscape within cyber security, it will be necessary to review and modify standards and controls regularly.

When determining the appropriate security requirements, the Smart Grid Interoperability Panel (SGIP) Cyber Security Working Group (CSWG) recommends performing a security risk assessment, including identifying vulnerabilities, impacts, and threats, from a high-level overall functional perspective.[9] The primary goal, as stated by CSWG, should be on prevention.[10] The output of this type of risk assessment becomes the basis for the selection of security requirements and the identification of security requirements gaps.[11] The OpenHAN Task Force (TF), in conjunction with UCAIug SG Security Working Group, evaluated the security risks associated with the HAN to determine if adequate security requirements are included in the HAN SRS (see Appendix 4.2). The results of this evaluation provide justification for the selection of security controls that support cyber security objectives as defined by stature[12]:

Confidentiality

"Preserving authorized restrictions on information access and disclosure, including means for protecting personal privacy and proprietary information…" [44 U.S.C., Sec. 3542]

A loss of *confidentiality* is the unauthorized disclosure of information.

Integrity

"Guarding against improper information modification or destruction, and includes ensuring information non-repudiation and authenticity…" [44 U.S.C., Sec. 3542]

A loss of *integrity* is the unauthorized modification or destruction of information.

[9] Second Draft NISTIR 7628 Smart Grid Cyber Security Strategy and Requirements – Feb 2010, page 12 and NIST Framework and Roadmap for SG Interoperability Standards, Release 1.0, page 112

[10] Ibid

[11] Ibid

[12] Ibid, page 76

Availability

"Ensuring timely and reliable access to and use of information…" [44 U.S.C., SEC. 3542]

A loss of *availability* is the disruption of access to or use of information or an information system.

The levels of potential impact for each security objective are denoted as low, moderate, or high and are defined in FIPS 199[13]. In addition, the OpenHAN TF and the UCAIug SG Security Working Group reviewed the security requirements applicable to the HAN, which were identified by the CSWG[14] and mapped them to the HAN SRS security requirements to identify any gaps. This analysis concluded that the HAN SRS follows the applicable Department of Homeland Security (DHS) recommendations for control systems security as identified by the CSWG in the Second Draft NISTIR 7628 Smart Grid Cyber Security Strategy and Requirements – Feb 2010.

1.7 HAN SRS Framework

This HAN SRS was developed from the eight-layer interoperability framework provided by the GridWise Architecture Council (Figure 3)[15]. Referred to as the "GWAC Stack", this diagram provides a context for categorization of smart grid interoperability efforts and classifications for exchanges of information.

[13] FIPS 199, *Standards for Security Categorization of Federal Information and Information Systems*, February 2004, pages 2-3

[14] Second Draft NISTIR 7628 Smart Grid Cyber Security Strategy and Requirements – Feb 2010, Table 3.5 – Allocation of Technical Requirements to the Logical Interface Categories pages 93-95

[15] GridWise® Interoperability Context-Setting Framework, March 2008, page 5

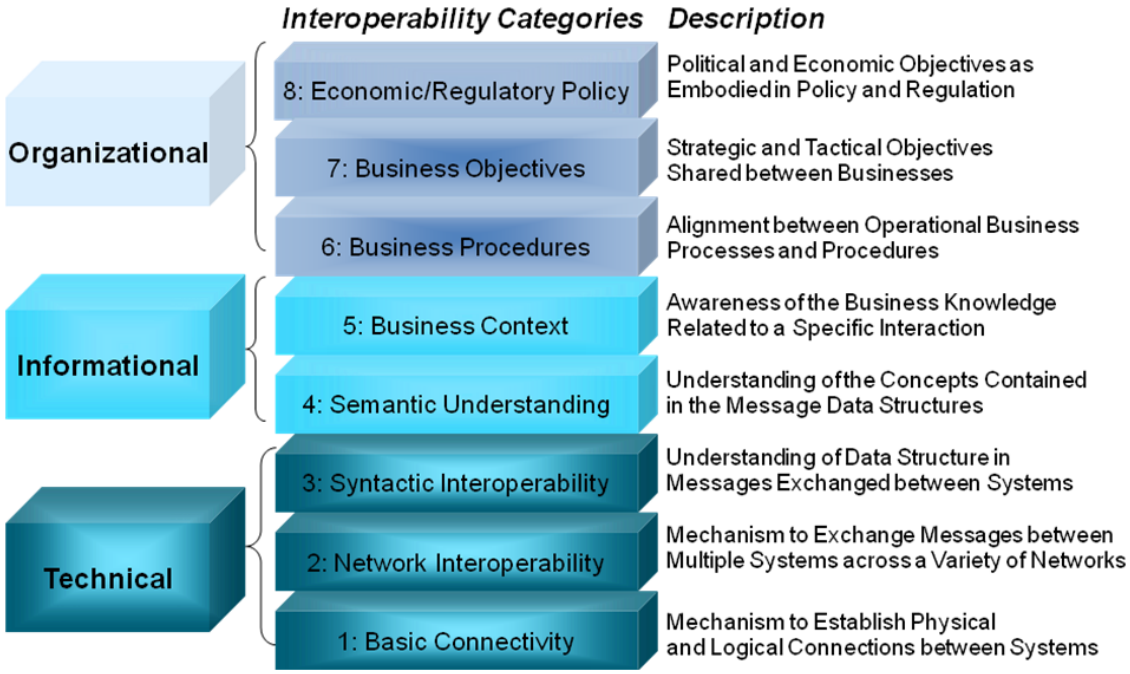

Figure 3: Interoperability Framework

The HAN SRS takes a top-down approach to interoperability by focusing on organizational and informational interoperability categories 8 through 4. Policy and business drivers are intended to inform ongoing and future technical efforts that define syntax and formats for information exchanges. Achieving success within and between these layers requires negotiation, compromise, and agreements between various stakeholders across numerous organizational boundaries. As detailed in the following Table 1[16], high-level political and regulatory activities set the context for the initial development and this revision of the HAN SRS by creation of new policies, laws, and regulations. The remaining interoperability categories (i.e. layers 7 through 4) have been addressed by the multiple organizations who have participated in the OpenHAN 2.0 discussions, resulting in this HAN SRS.

[16] The format of this table is from Section 5 Examples of Applying the Framework of the GridWise® Interoperability Context-Setting Framework, March 2008, page 36

1
2

Table 1: HAN SRS Framework

Interoperability Category	Tools, Systems, Key Actors	Interoperation across organizational boundaries where agreements must be reached
ORGANIZATIONAL		
8: Economic / Regulatory Policy Political and economic objectives as embodied in policy and regulation	• Lawmakers (e.g. federal, state, international, etc.) • Policy makers (e.g. FERC, National Association of Regulatory Utility Commissions (NARUC), Public Utility Commissions, White House Office of Science and Technology Policy (OSTP), etc.) • Government organizations (e.g. Department of Energy (DoE), NIST Smart Grid Interoperability Panel (SGIP), etc.) • Etc.	The following are examples of different policy, regulatory, and economic objectives that influenced the development of this HAN SRS. • Energy Independence and Security Act (EISA 2007) declares policy of US is to support a smart grid, directs NIST to coordinate the development of smart gird interoperability standards for smart grid devices and systems; directs FERC, when sufficient consensus is reached, to adopt standards necessary to insure smart-grid functionality and interoperability • American Recovery and Reinvestment Act (ARRA) 2009 funded NIST and DOE SGIG • DOE funds 100 Smart Grid Investment Grant (SGIG) projects • FERC issues Smart Grid Policy • NIST publishes v1.0 of the Interoperability Framework and Roadmap; recognized UtilityAMI 2008 HAN SRS as a set of requirements for the HAN • SGIP established as a public-private partnership; Governing Board HAN Task Force, Cyber Security Working Group (NISTIR 7628) • CPUC Energy Action Plan and AMI Directives • CEC J45 Reference Design for PCTs • 2007 Texas Public Utilities Regulatory Act encouraged smart grid networks be deployed as rapidly as possible • 2007 PUCT Advanced Metering rule set forth requirements for advanced metering deployments • PUCT Advanced Metering Implementation Project (Project 34610) defined requirements for data exchange and HAN interfaces. • Michigan 21st Century Energy Plan • Etc. • HAN SRS Section 1 Introduction
7: Business Objectives Strategic and tactical objectives shared between businesses	• Policy Makers • Utilities and Service Providers • Hardware and Software Technology Vendors • Appliance and HAN Device Manufacturers • DER and PEV Manufacturers • Consultants	• OpenHAN Task Force forms OpenHAN 2.0 Working Group to create the next version of HAN SRS. • Over 130 individuals, representing more than 80 companies and organizations; collaborated over a 10-month period to develop the HAN SRS v2.0. • HAN SRS Section 2 Overall Description o Guiding Principles o Architectural Considerations

Interoperability Category	Tools, Systems, Key Actors	Interoperation across organizational boundaries where agreements must be reached
6: Business Procedures Alignment between Operational Business Processes and Procedures	• Utilities • Hardware and Software Technology Vendors • Appliance and HAN Device Manufacturers • DER and PEV Manufacturers • Service Providers • Consultants	• HAN SRS Section 1.6 - Security in the HAN Environment • HAN SRS Section 2.2 - Architectural Considerations • HAN SRS 2.2.2 – Commissioning, Registration, and Enrollment
INFORMATIONAL		
5: Business Context Awareness of the business knowledge related to a specific interaction	• HAN Device Manufacturers • Service Providers	• HAN SRS Section 3 - System Requirements o Section 3.1 – Logical Device Mapping o Section 3.2 - Requirements Framework o Section 3.3 - Requirements Assumptions
4: Semantic Understanding Understanding of concepts contained in the message data structures	• HAN Device Manufacturers • Industry Alliances and Standards Bodies	• HAN SRS Section 3 HAN System Requirements • HAN SRS Section 4.1 – Other Use Cases and Documents Reviewed • Joint collaboration with SAE, SG-Security • Knowledge transfer to/from trade alliances and standards organizations

1
2

2. Overall Description

The UCAIug HAN SRS provides the foundation of the energy HAN in which HAN Devices operating within a premises are able to engage with a Service Provider as much or as little as the Consumer wishes. The HAN may be deployed in different physical environments (e.g. multi-dwelling units, large single or two story house, strip mall, etc.).

This section defines the guiding principles the OpenHAN Task Force adopted to frame the capabilities and constraints of the system, the Architecture for HAN Device interaction with the Service Provider that permits a highly adaptable and flexible system depending on consumer preference, and the assumptions for the system used as a starting point for drafting the Use Cases and Requirements found in Appendix 4.1 and Section 3, respectively.

2.1 Guiding Principles

The guiding principles represent high level expectations used to guide and frame the development of the functional and technical requirements in this document. These expectations include the capabilities which are necessary to support policy directives, interoperability, and smart grid functionality.

The principles are authoritative and define the HAN implementation starting point. A complete implementation will provide technical methods and processes which meet or exceed a stated capability and adhere to the stated constraints. These principles, as stated, drive and define the functional characteristics and are the basis for the HAN Use Cases.

1. Support Two-way Communication Between HAN Devices and Service Provider(s)

Description

HAN Devices, including AMI meters, must be capable of connecting to a communications network. By utilizing an Energy Services Interface (ESI), HAN Devices and Service Provider(s) gain the ability to engage in two-way communications.

As such, the ESI and communications network may carry various types of data, including sensitive, confidential, and control data. Security and privacy protections are paramount; therefore appropriate levels of protection must be provided for these types of communications.

The level of security required for communications depends on a device's relationship with the ESI. In this HAN SRS there are three separate processes for different levels of communicating with the ESI: Commissioning, Registration, and Enrollment. Based upon which processes a HAN Device completes, the ESI will communicate the appropriate type of data with the appropriate security measures.

Rationale

Fundamental HAN capabilities (e.g. real-time monitoring, dynamic pricing, demand response programs, PEV programs, etc.) are possible when a secure two-way communication path between Service Provider(s) and HAN Devices is present. The ESI is the critical component that makes this secure communication possible.

2. Supports Load Control Integration

Description

Load control is the concept of load being managed (e.g. deferred, eliminated, cycled, reduced, etc.). A load control device (e.g. PCT, Smart Appliance, Pool Pump Controller, EMS, etc.) has the capability to reduce the peak power consumption of the equipment under its control. These devices within the Consumer's premises can be used to reduce load through direct and indirect control. Control signal execution should not in any way compromise safety systems built into HAN Devices or compromise the ability of the HAN Device to complete the task previously initiated (e.g. mid-cycle interruptions, such as, adding bleach to the bleach cycle, will be processed appropriately by the smart appliance to avoid damage to clothes).

Rationale

A capability to interface and integrate with load control systems improves the operational efficiency of the electrical distribution system, and as such, it is critical that this capability be enabled within the HAN. This also enables the Service Provider to offer various programs that help consumers adjust their energy usage based on events external to the consumer (such as grid demand stress or generation failure). Enabling load control integration via the HAN will provide consumers with more choices with respect to energy management and energy management services.

3. The AMI meter provides the HAN with direct access to Consumer-specific usage data

Description

The AMI meter provides the HAN with access to Consumer-specific usage data (e.g. instantaneous usage, interval usage, volts, amps, VAR, power factor, etc.).

Rationale

One of the main requirements for energy management and conservation is a better informed Consumer. By providing Consumers with more timely and detailed usage information, Consumers will be able to make informed choices about when and how they consume energy. Access to this usage data will enable a new class of energy services and products. Applications may use the usage data to automatically optimize premises consumption (e.g. EMS, PEV programs, pool pump, PCT, etc.). With direct access to usage data, Consumers need not wait until the end of the month to get an indication of how their bill is affected by their choices in energy consumption. Since the energy usage from the AMI meter is recorded in shorter time intervals, the Consumer can more

readily observe the impact of changing energy usage patterns and utilize that information to adjust consumption through manual or automated means.

4. Provides a Growth Platform for Future Products Which Leverage the HAN and Meter Data

Description

A growth platform is typically an opportunity identified as providing value to consumers and thereby providing business opportunities. The HAN is an example of a strategic growth platform. Strategic growth platforms are longer term initiatives where the initiative and results span years. While AMI enables the Utility to exchange information with a HAN via the Utility ESI, the growth platform is not limited to the Utility, but extends to any organization that wants to develop products or services leveraging the HAN and meter data.

Rationale

The HAN environment enables a new class of energy services and products and is expected to support many innovative applications and devices, including the next generation of applications (e.g. DER, PEV programs, Smart Appliances, EMS, other energy applications, etc.) as the technology, information, and communication capabilities of the HAN mature. By supporting open standards (see Principle 10), it is expected that many Service Providers and vendors will be able to expand the capabilities of the HAN by developing innovative products for this emergent HAN market.

5. Supports Three Types of Messaging: Public Information, Consumer-Specific Information, and Control Signals

Description

To support the anticipated growth in the HAN market, the system must provide for various types of messaging. These message types may include Public Information, consumer-specific information, and Control Signals. Public messaging is the communication of material which is publicly available and of general interest to all or a large identifiable subset of consumers. Consumer-specific messaging is information which is specific to a Consumer. Contents of these types of messages might include usage, pricing, billing, etc. Control Signals are used to support applications such as load-reduction, demand response, load limiting, etc. (see Principle 2).

Each message type warrants individual security and privacy analysis and treatment. Consumer-specific information messaging implies a level of privacy and additional security measures and methods are warranted. Control Signals require reliable and secure delivery for accountability to a Service Provider program.

Rationale

These types of messages support innovation in the HAN market (e.g. HAN Devices, software applications, Service Provider programs, etc.). Service Providers and HAN vendors will compete to develop and offer Consumers products and programs, which will use these types of messages.

6. Supports End-Use Metering and other Utility Meters

Description

End-use metering is when an additional meter may be installed in the premises to record DER production or to measure discrete loads (e.g. PEV, etc.). DER systems are small-scale power generation technologies used to provide an alternative to or an enhancement of the traditional electric power system.

Additionally, the HAN architecture does not presume use of only electric meters. The Utility ESI may also communicate with gas and water meters and transmit their data through the HAN (e.g. to an IHD) or through a backhaul network (e.g. AMI network, internet, etc.) for transfer to an appropriate entity (e.g. an electric utility could gather water meter information and pass that information to the water utility).

Rationale

The ability to support communication to multiple HAN Devices provides greater value to the Consumer and Service Provider by facilitating automation and reducing redundancy in the systems required to capture metering information. As more homes and business become “green” it is anticipated that the HAN will need to support DER sources such as solar panels, small wind turbines, or PEVs that may discharge energy back into the grid. In addition, non-revenue grade metering of end-use devices can provide consumers with additional information on the energy and cost associated with end-uses such as individual circuits, appliances, or plug loads.

7. Supports Distributed Energy Resources

Description

The HAN should enable monitoring, management, and optimization of small scale Distributed Energy Resources (DERs) (e.g. photovoltaic, wind, fuel cell, diesel, and micro combined heat and power (CHP) generation systems) within Consumer premises. Ongoing innovations and improved economics for DER systems have increased Consumer awareness and interest in these types of solutions. Presently there exists the potential for far greater deployment of these resources at levels which begin to influence the operation of generation, transmission, and distribution grids. Plug-in electric vehicles add additional complexity as their batteries provide storage capacity and allow them to act as large sources or sinks of electricity.

Rationale

Widespread deployment of residential DERs brings both benefits and risks. DERs provide Consumers the ability to offset electricity bills and generate excess power that can be delivered back to the distribution grid for profit or credit. Renewable DERs like solar and wind are considered less polluting sources of energy; their use reduces overall dependence on fossil fuel-based generation sources. Renewable DERs can also help utilities achieve renewable portfolio standard (RPS) goals, as some regions allow utilities to purchase

renewable energy credits (RECs) from Consumers. DERs also serve to provide critical back-up power to Consumers in times of grid outage or failure.

However, greater DER adoption introduces additional complexity to the power system. The current power grid was designed to accommodate distribution of electricity to end-use Consumers from centralized large-scale generation facilities. As power generation becomes smaller, more distributed, and more intermittent due to renewable generation sources, maintaining stability and reliability of the power grid becomes a greater challenge for utilities. By integrating DER systems with the HAN, utilities, vendors, and service providers can develop products that provide visibility and greater control over DER systems. These capabilities will allow for innovative optimization of DER systems for the benefit of individual consumers and the overall power grid.

8. Consumer Owns the HAN

Description

The Consumer owns and controls the HAN. For various reasons and under designated conditions, the Consumer may cede control of specific HAN Devices and functions in accordance with a Service Provider's program. A Service Provider cannot manage a Consumer's registered HAN Device without receiving permission from the Consumer. The Consumer gives a Service Provider this permission by enrolling a registered HAN Device in the Service Provider's program. Some such programs may include providing the Consumer with HAN Devices where the ownership of the device is retained by the Service Provider.

Rationale

Service Providers and vendors may offer Consumers innovative applications, programs, and devices which utilize the HAN and the AMI meter data. However, the Consumer decides which applications, products, information, programs, devices, etc. are best suited to meet the Consumer's energy goals and needs.

9. HAN Devices Present Additional Security Considerations

Description

An ESI manages the boundary between a HAN and a Service Provider's network (e.g. Utility AMI Network). As such, ESI implementers and Service Providers must carefully consider the security implications of device tampering and compromised devices/networks when designing their systems and programs. It should be expected that certain individuals will attempt to use compromised HAN Devices and networks to launch attacks on a Service Provider's network, to defraud a Service Provider's program, to damage the Consumer's HAN or other HAN Devices, or to expose consumer-specific information. It should also be expected that a HAN Device may not accurately report the correct status and action due to tampering.

Rationale

HAN Devices are under the physical control of the Consumer and are typically located inside the Consumer Premises. Just like existing in-home networks, the Consumer bears responsibility for the security and integrity of their network and its attached devices. It should be expected that HAN Devices may be tampered with inside the home, and that external parties may find ways to compromise devices on the HAN. It is important that appropriate security measures are taken so that the HAN does not comprise the Service Provider network's integrity and vice-versa.

10. The HAN is enabled by Open and Interoperable Standards

Description

The HAN is enabled by open and interoperable standards.

> **Open specification:** standards should be developed and maintained through a collaborative, consensus-driven process that is open to participation by all relevant and materially affected parties and not dominated by, or under the control of, a single organization or group of organizations. As important, the standards resulting from this process should be readily and reasonably available to all for Smart Grid applications.[17]
>
> **Interoperability:** The capability of two or more networks, systems, devices, applications, or components to directly exchange and readily use information—securely, effectively, and with little or no inconvenience to the user.[18]

Rationale

The use of open and interoperable standards is a key to accessibility, availability, innovation, and wide-spread adoption. Standards provide for (1) cyber security that protects systems and data, (2) interoperable components that protect investments in technology and enable growth in the HAN ecosystem, (3) competition among consumer products companies, which drives down costs while increasing choices for Consumers, (4) reduced maintenance and support costs caused by proprietary solutions, and (5) a common understanding of information exchange.

2.2 Architectural Considerations

The architectural consideration section is not binding. That is, this section of the document is not considered “requirements.” Rather, this section of the document provides context to the OpenHAN Task Torce architectural considerations during the development of this HAN SRS document. In general, this HAN SRS is architecture

[17] NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0. http://www.nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf

[18] Recovery Act Financial Assistance, Funding Opportunity Announcement. U. S. Department of Energy, Office of Electricity Delivery and Energy Reliability, Smart Grid Investment Grant Program Funding Opportunity Number: DE-FOA-0000058.

agnostic. The requirements are targeted at logical devices. The following sections simply provide additional clarifications and context.

In November 2009, NIST formed the Smart Grid Interoperability Panel (SGIP) and seated the initial SGIP Governing Board (SGIPGB). The HAN has been a topic of interest and the SGIPGB formed a HAN Task Force to make recommendations to the SGIPGB on the issue of HAN Architecture. Since the view of HAN architecture is evolving, it is expected that this HAN SRS v2.0 will require updating as the SGIPGB HAN Task Force and the Smart Grid Architecture Committee (SGAC) complete their work on HAN architecture.

2.2.1 Energy Services Interface (ESI)

An ESI provides a particular logical function in the HAN. It is an interface which enables secure communications between authorized parties (e.g. Utility, Consumer, non-Utility Service Providers, EMS, etc.) and all Commissioned HAN Devices that are Registered to it. The HAN architecture allows for more than one ESI in a Consumer premises. Each ESI creates an independent logical segmentation within the premises. These logical segmentations can be viewed as separate independent networks, each with its own security. HAN Devices (e.g. EMS, internet gateway, etc.), which are active on multiple networks, must have a logical separation between those networks. This does not preclude implementation of multiple logical networks existing on a common single physical network.

An important ESI is the Utility ESI which enables secure interactions between Commissioned HAN Devices Registered to it and the Utility AMI. Security on this interface is robust and comprehensive in order to protect Utility assets (e.g. electric grid, AMI, etc.). This ESI is the unique interface providing real-time energy usage information from the AMI meter to HAN Devices and is protected with cryptographic methods. Who (e.g. Utility, Consumer, non-utility Service Provider, etc.) has access to communicate with the Utility ESI is a matter of law or regulatory policy. In addition, the type of access an authorized party has to Registered HAN Devices is subject to the program in which the HAN Device is Enrolled. Additional ESIs may be installed in the Consumer premises to create additional logical HANs (e.g. EMS, a Service Provider program, etc.). These ESIs must provide security to protect Consumer assets and data. Communication to Commissioned HAN Devices Registered to these ESIs may be through alternative communication networks (e.g. internet, cell phone network, EMS, etc.).

2.2.2 Commissioning, Registration, Enrollment

To create a Home Area Network, devices must determine which network to join, request admission, and exchange device parameters. This initial process is called Commissioning and allows devices to exchange a limited amount of information (e.g. network keys, device type, device ID, initial path, etc.) and to receive public information. This process is initiated by the Installer powering on the device and

following the manufacturer's instructions. Once a HAN Device has completed the Commissioning process it may go through an additional process called Registration.

The Registration process is a further step involving authentication and authorizing a Commissioned HAN Device to exchange secure information with a specific ESI and other HAN Devices Registered with that ESI. Registration creates a trust relationship between the HAN Device and that ESI and governs the rights granted to the HAN Device in that ESI's network. This process requires coordination between the Installer and the Service Provider. Registered HAN Devices can communicate public information and consumer-specific information with other Registered HAN devices and with the ESI, including meter usage data. In some jurisdictions Commissioning and Registration are combined into one process called provisioning.

The final process is Enrollment. This process is only applicable when the Consumer wants to sign their HAN Device up for a specific Service Provider program (e.g. demand response, PEV special rate, pre-pay, etc.). Enrollment is required for the Service Provider to get specific device addresses or device information. In this process the Consumer selects a Service Provider program and grants the Service Provider certain rights to communicate with or control their HAN Device. A HAN Device must be Commissioned and Registered prior to initiating the Enrollment process. This process requires coordination between the Consumer and the Service Provider. Each of these processes is discrete but they may be combined by a Service Provider in order to provide a seamless Consumer experience.

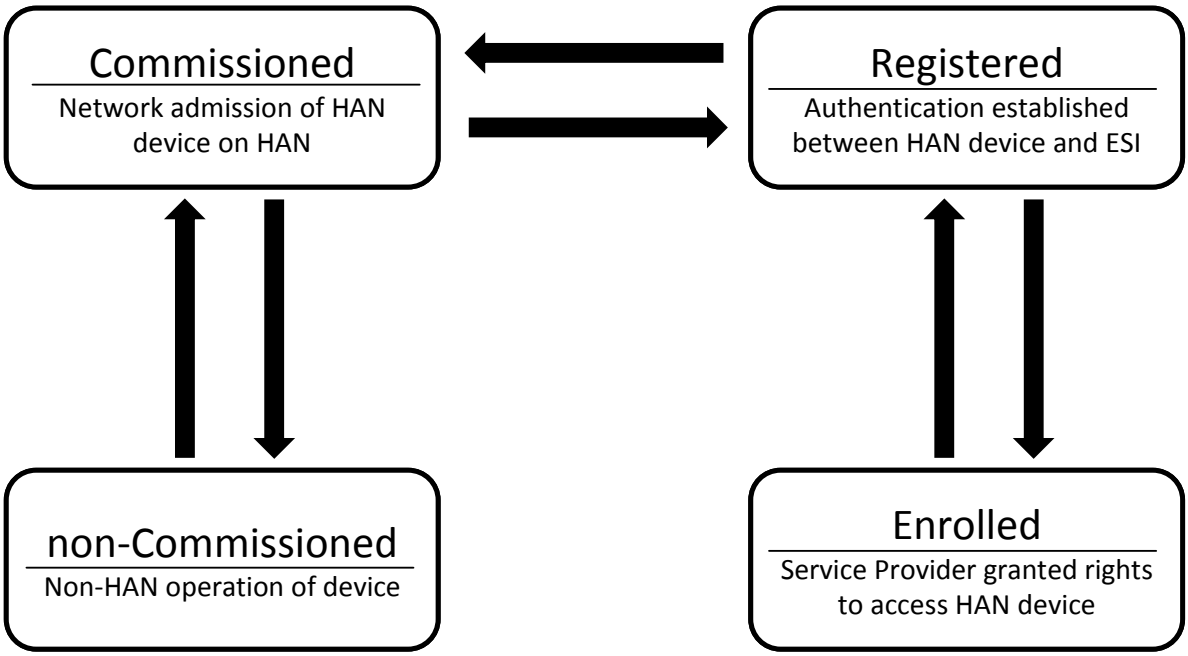

Figure 4: HAN Device Status

Figure 4 shows the non-Commissioned, Commissioned, Registered, and Enrolled states in which a HAN device may exist. The entry criteria for each state are shown below the horizontal line in each state. The arrows indicate the valid state transitions. The HAN SRS provides high level requirements for these state transition processes, which remain technology agnostic. The transitions are reversible between each state, as shown by arrows in both directions between states.

Figure 5 shows the type of communication a HAN Device may engage in, which is dependent upon its relationship with the ESI and the Service Provider.

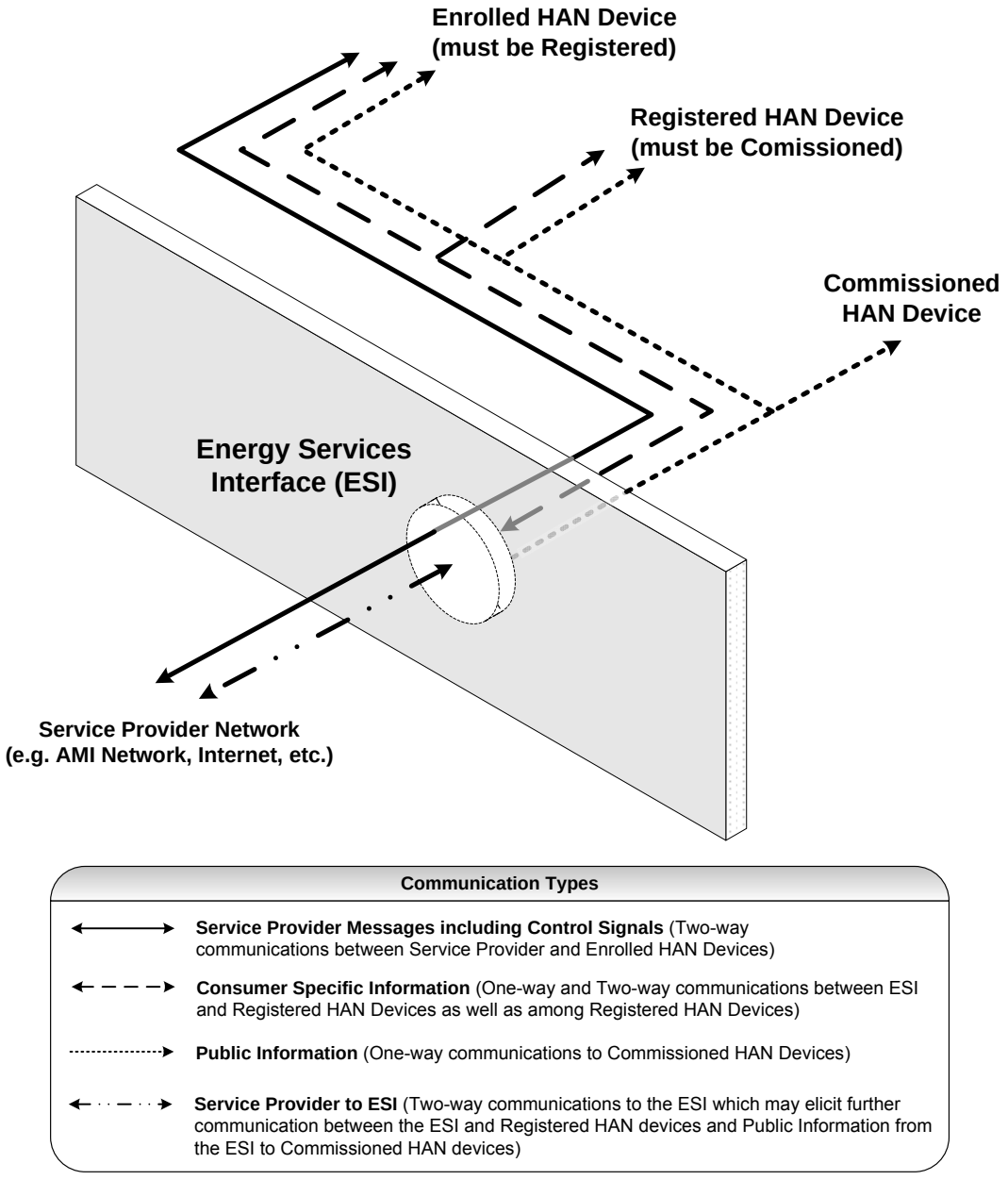

Figure 5: Communication in the HAN

2.2.3 Device Ownership

The HAN SRS as a whole is agnostic to device ownership. This document recognizes consumer rights, and this sentiment is stated explicitly in Section 2.1 Guiding

Principles. With that being said, the architecture section does touch on additional aspects of ownership and control. The architecture section makes a further assumption beyond the guiding principle that devices in the premises can be supplied by the Utility, a non-utility Service Provider, or the Consumer. In addition, HAN Devices supplied by various parties (e.g. Utility, non-utility Service Provider, Consumer, etc.) may exist in the same HAN. This HAN SRS provides for architecture flexibility and supports any desired configuration.

2.2.4 Public Information

Some jurisdictions may require the ability to broadcast Public Information to devices in the consumer premises. This is one-way communication that requires Commissioning of the HAN Device but not Registration. This type of communication has a fair number of vulnerabilities and should be used only for information a Service Provider is comfortable transmitting in an unsecured manner.

2.2.5 Cohabitation

Some HAN Devices may reside on multiple ESIs, including the Utility ESI. Since there can be vulnerabilities related to HAN Devices, the ESI should start with the assumption that a HAN Device should not be trusted and it must provide a means for protecting the Service Provider network and assets (e.g. AMI meter, etc.).

2.2.6 Deregulated Electric Markets

The electric market structure varies from jurisdiction to jurisdiction and country to country. In certain deregulated markets, retail energy sales and the actual delivery of electricity are segmented. In such markets, the Utility is the entity which delivers the electricity and the Service Provider is the entity which provides Consumer programs for HAN Devices and may or may not provide retail energy sales to the Consumer. In addition, in some jurisdictions, metering may be a competitive service. This HAN SRS is agnostic to electric market structure and may be used regardless of the market structure.

2.2.7 External Interfaces

The HAN SRS was written to support external interfaces to the HAN. The ESI requirements specified in the HAN SRS do not presuppose an architecture in which the only interface to the HAN is the Utility ESI. Pricing information, Control Signals, and messaging may be provided from a non-Utility Service Provider (e.g. Retail Energy Provider, Demand Response Aggregator, etc.) through a separate ESI. In this model, the AMI meter would continue to provide premises consumption information (e.g. real-time metrology) through the Utility ESI and would be part of the HAN. Customers may also have an external interface (e.g. internet, cell phone network, etc.) to communicate with devices on their HAN to enable remote configuration, monitoring, and other applications.

2.2.8 Special Applications

2.2.8.1 PEV

PEVs and their associated equipment (e.g. EVSE, EUMD) are unique HAN devices because they combine mobility with numerous other applications (e.g. demand response, pricing, energy management, energy storage, metering, etc.). This HAN SRS focuses primarily on charging a PEV at the primary residence. It also includes requirements dealing with energy storage and mobility, however, comprehensive and robust requirements dealing with the complex nature of the bi-directional flow of energy and charging at locations other than the primary residence will be left to future versions of the HAN SRS once the technology, policy, and market design are more fully developed.

From an architectural perspective, a PEV application includes multiple functions that involve HAN communications and these functions may or may not be included within a single HAN device. These functions are the PEV, the Electric Vehicle Supply Equipment (EVSE) and End-Use-Measurement Device (EUMD). The PEV includes all associated vehicular components (e.g. the battery system, propulsion system, sensor network, HAN communications interface, etc.). The EVSE can be comprised of multiple devices used in charging the vehicle (e.g. PEV connectors, attachment plugs, power outlets, DC charger, HAN communications interface, etc.) specified by applicable SAE standards (e.g. SAE J1772 ™, J2836™, J2847 & J2931.) that provide for the safe transfer of electrical energy from premises wiring to the PEV batteries. This can be 120V or 240V AC or DC depending on the EVSE design and the connection used. The EVSE is generally found in two configurations: (1) a specialized cord set or (2) a wall or pedestal mounted box. The second configuration can either deliver 240V AC to the PEV or, if equipped with an inverter, can deliver DC energy to the PEV. The EUMD measures the energy consumed by a PEV and communicates that information back to the HAN. The EUMD is expected to either be contained within the EVSE or at least within the EVSE circuit to the PEV.

PEVs and their related components are still in the early stages of commercial development and rollout to the consumer. Multiple system architectures for PEVs are possible and probable. The requirements in this HAN SRS are not intended to assume or preclude any viable system architecture and are based on the following assumptions:

1. The PEV, the EVSE, and the EUMD may all contain HAN communications interfaces and will be capable of becoming Commissioned and Registered HAN devices.

2. The PEV, EVSE, and EUMD are logically separate functions. The EVSE is located external to the vehicle. The EVSE and EUMD may be co-located in a single device or located in physically separate devices. The EUMD is a single device located in the circuit to the PEV.

3. If EVSE and EUMD are one physical device, a single HAN communications interface is anticipated; however dual communications in the single physical device may exist.

There are several PEV technical aspects related to implementation that influence the PEV interaction with the HAN. The location of the EVSE may be a fixed installation in the premises (e.g. permanently installed in a garage, etc.) or it could be a portable device connected to the premise and the PEV. The metering accuracy of the EMUD may or may not be revenue grade. In addition, the EMUD may be a sub-meter in the Consumer premises or it may be a separate meter dedicated to measuring only the PEV consumption.

2.2.8.2 Energy Management System (EMS)

In this HAN SRS, an EMS is a logical function to manage energy consumption in the premises. Physically, it may reside in another hardware device (such as a PCT, In-Home Display, computer, cable set-top box) or it may be a separate and independent device. At its simplest, the EMS may manage a few devices based on simple rules or enable the Consumer to access devices in the premises remotely from mobile phones. A more complex EMS may optimize energy usage or costs for devices within the premises, utilizing algorithms that receive as inputs many objectives and aspects of the current state of the grid and premises. These varied EMSs will also have a wide range of communications capabilities: some, but not all, will communicate outside the premises; some will exchange information and control messages with one or more ESIs in the premises; some will control HAN Devices which are also enrolled in Service Provider programs.

This SRS recognizes the evolving architectures for premises energy management and the role of the EMS over the installed lifetime of the HAN Devices. An EMS is not a required function in a HAN; however, as the Consumer adds more smart devices (e.g. PCT, smart appliance, PEV, etc.) to their premises and desires a more sophisticated and automated HAN ecosystem, an EMS may be installed. The EMS may provide conservation-related local control of HAN Devices using various inputs (e.g. instantaneous usage obtained from the AMI meter, weather information available on the Internet, Consumer preferences, etc.). This type of control could begin with inexpensive HAN Devices such as light dimmers and pump relays which are controlled only by an EMS for local energy management. Over time, this could extend to those devices enrolled in Service Provider programs. As even more smart devices are purchased, an EMS may perform advanced optimization for the entire premises, balancing Consumer preferences with Service Provider program requirements and energy production from DER.

2.2.8.3 Distributed Energy Resources (DER)

Distributed Energy Resources (DER) are small, modular, energy generation and storage technologies that are located at a premises' service delivery point. DERs generate electricity which may provide for all or a portion of the premises' electrical needs. A DER may be interconnected to the Utility electric distribution system and any net energy flowing on to the electric grid may be recorded in a separate channel on the AMI meter. For purposes of the HAN SRS, a DER is a HAN Device with functionality that measures and communicates its full energy production. The DER production may also be managed by an EMS which optimizes the premises energy consumption.

2.2.9 Architectural Scenarios

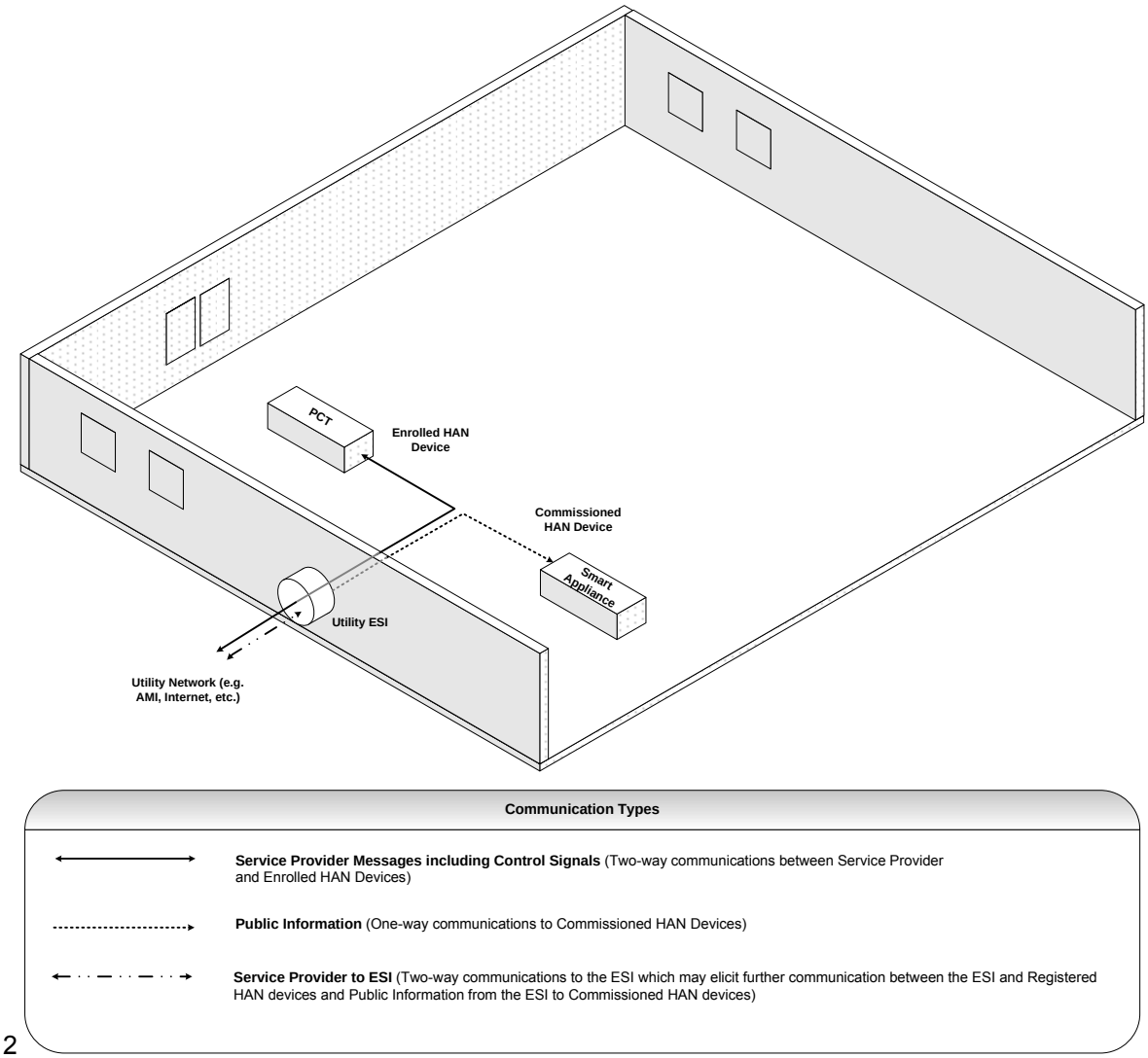

Figure 6: Scenario One (Inception) –Utility communicates with the PCT, which is Enrolled in the Utility Demand Response program. The Utility provides Public Information to all Commissioned HAN Devices (i.e. PCT and Smart Appliance). The Utility ESI is located in the AMI meter.[19]

[19] Adapted from Southern California Edison (SCE) Edison SmartConnect™

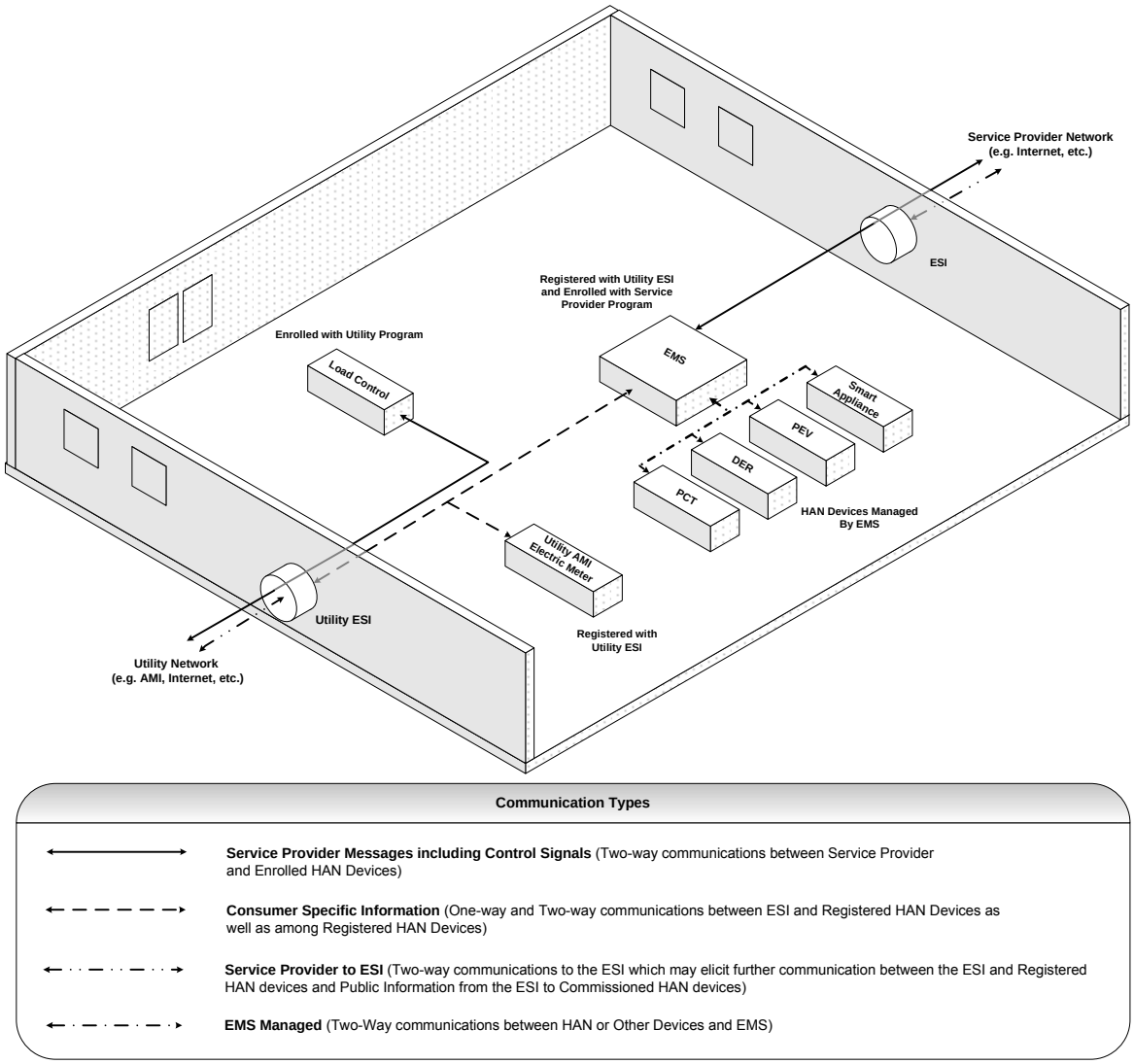

Figure 7: Scenario Two (Consumer Choice Example) – Load Control HAN Device is Enrolled in a Utility program. Utility communicates with Load Control device via the Utility ESI. EMS is Registered with the Utility ESI in order to receive usage data from the AMI meter. Several devices are under the management of the EMS. EMS is Enrolled in a Service Provider program. Service Provider communicates with EMS via the ESI using the Internet.[20]

[20] Ibid

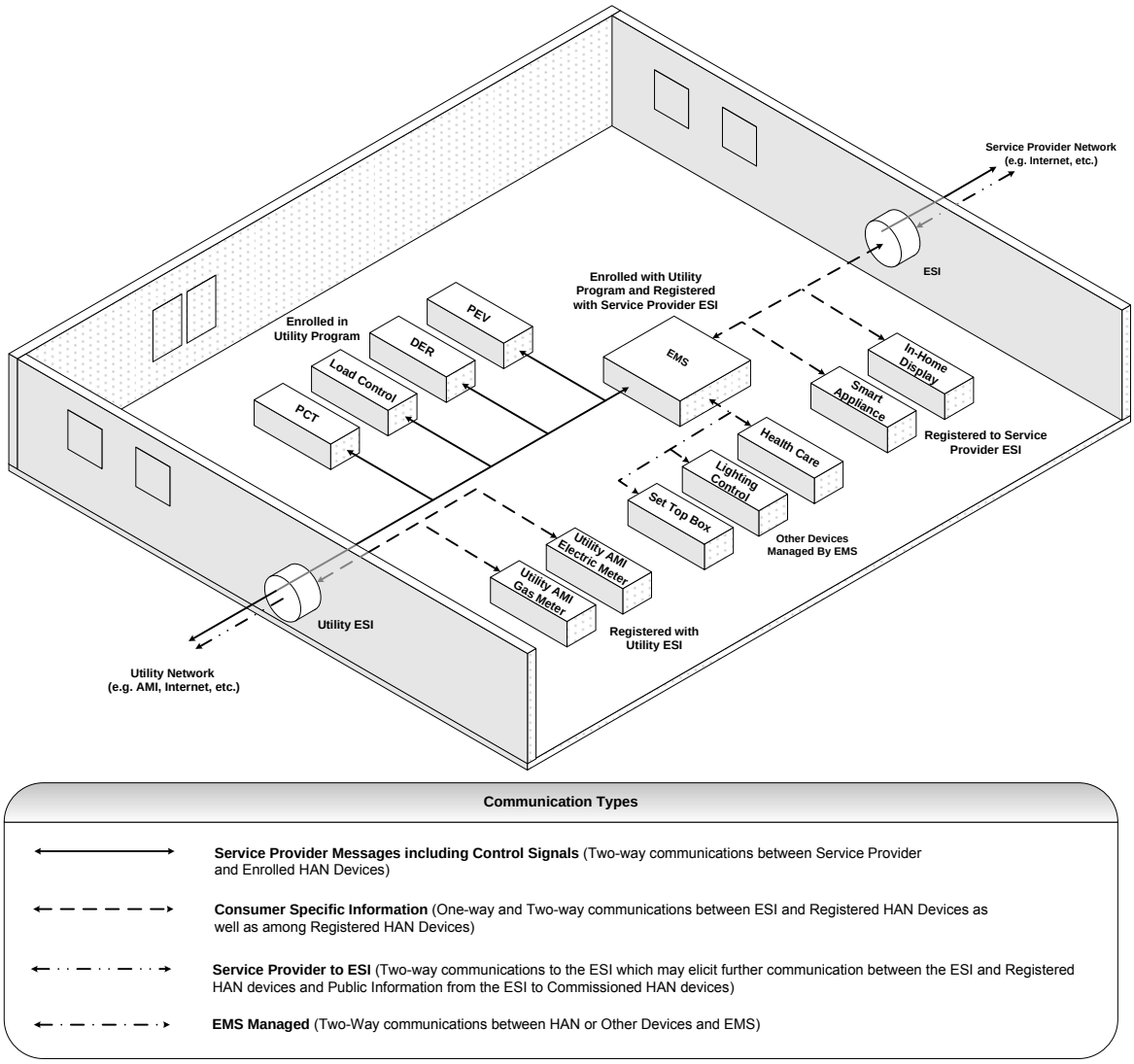

Figure 8: Scenario Three (Mature System) - Many HAN devices are Enrolled in Utility programs, including the EMS. Utility meters are Registered with the Utility ESI. The EMS, IHD, and Smart Appliance are Registered with a Service Provider ESI and communicate with each other. The EMS also manages other devices[21].

[21] Ibid

3. HAN System Requirements

The HAN System Requirements are the main focus of this document and provide the most important information to the various HAN stakeholders. They define the HAN to enable successful functionality for Consumers, Utilities, Service Providers, and vendors.

3.1 Requirements Mapping to Logical Devices

The HAN SRS requirements are written with the key word “shall”, however, different HAN Devices may include only a subset of these requirements to provide the device functionality. In order to provide guidance to Service Providers and vendors, the OpenHAN Task Force mapped each set of requirements to functional HAN Devices in a table provided at the end of each section. The tables indicate which requirements the OpenHAN Task Force considered needed for the Commissioning Process (CP), for the Registration Process (RP), for Security (S), for application functionality (BF), as Optional (O), or if the requirement was Not Applicable (NA) for the function of the device. These tables may be used as a template or starting point for Service Providers in their discussions with vendors and in their procurement process. Vendors may use these tables as guidance for producing devices and software which enables basic HAN functionality and for providing additional functionality in order to provide competitive differentiation. The tables are for reference only and should not limit the needs of Service Providers nor limit vendor innovation.

3.1.1 Mapping Categories

The categories used for the mapping of the requirements to the logical device types are defined below

- **CP or Commissioning Process** – Minimum requirement needed for the Commissioning process. These requirements are mandatory and must be included to support the process of Commissioning a HAN Device on the HAN.
- **RP or Registration Process** - Minimum requirement needed for the Registration process. These requirements are mandatory and must be included to support the process of Registering a HAN Device on the ESI.
- **BF or Basic Functionality** – Minimum requirement that the OpenHAN TF recommends is needed to support the basic functionality of the logical HAN Device. This assumes that the device at a minimum has been Commissioned.
- **S or Security** – Minimum requirement needed for security in the HAN. These requirements are mandatory and must be included to protect the HAN against compromises to the confidentiality, integrity, and availability of the HAN.
- **O or Optional** – An optional requirement that may be included to support a Service Provider program or allow a vendor to differentiate their product.
- **NA or Not Applicable** - This requirement is not applicable to this logical HAN Device.

3.1.2 Logical Device Types

The list of logical devices chosen by the OpenHAN TF was limited to devices that were the most common at the time this document was written and is by no means exhaustive. This list is intended to expand and grow as new classes of devices are available and new Service Provider programs are developed. The logical HAN Devices are listed along with their primary functionality in the following Table 2. These devices may include multiple functions but for simplicity sake the mapping was done by primary function. A physical device will have one of these categories as its primary function but may implement one or more additional functions as well.

Table 2: Logical HAN Device Types

	Logical Device	Primary Functionality
1	Energy Services Interface (ESI)	Network Control and Coordination
2	Utility ESI	Network Control and Coordination
3	Programmable Communicating Thermostat (PCT)	HVAC Control
4	In-Home Display (IHD)	Display of Energy Information
5	Energy Management System (EMS)	Controlling end-device energy
6	Load Control	Resource Control
7	AMI meter	Energy Measurement
8	HAN Non-Electric Meter	Resource Measurement
9	Smart Appliance	Intelligent Response
10	Electric Vehicle Supply Equipment (EVSE)	Charging a PEV
11	Plug-in Electric Vehicle (PEV)	Electric transportation
12	End-Use Measurement Device (EUMD)	Metering of an end-device load

3.2 Requirements Framework

In creating the requirements, the OpenHAN TF considered a number of categories, such as:

- HAN Applications
- Communications
- Security
- Performance
- Operations-Maintenance-Logistics

HAN Applications are one of the most important categories from the Utility, Service Provider, vendor, and Consumer's perspective. Any application that is enabled through the HAN will have one or more of the following characteristics: Control, Measurement and Monitor, Processing, and Human-Machine Interface (HMI).

Control applications respond to Control Signals and price information. The simplest control application is direct control, which turns loads on or off. Control applications can also cycle, which means they turn the load on and off at configurable time intervals. More sophisticated control applications can limit the load of a device (e.g. Smart Appliance, etc.) based on configurable thresholds. These actions may be initiated by a discrete Control Signal which defines the specific type of action to take. They may also be initiated by a price signal which is interpreted by the control application in a HAN Device or an EMS as making such an action desirable. Control may also be exerted from within the HAN to fulfill Consumer objectives (e.g. manual, EMS, etc.).

Measurement and Monitor applications generally provide internal data and status. These applications include DER functionality where local energy input and output is measured and monitored. It can also have end-use metering functionality to measure and monitor device-specific energy consumption or production. A Consumer PEV, for example, can have end-use metering functionality as well as DER. Applications can be as simple as measuring and monitoring the environmental state or whether a device is on or off.

Processing applications consume, process, and act on external and internal data. These applications accept data from external systems and HAN measurement and monitoring applications. Applications with processing capability are generally more complex and costly. The following applications require processing:

- Energy Cost - Calculates current and overall energy cost
- Energy Consumption - Calculates current and overall energy consumption
- Energy Production - Calculates current and overall energy production
- Energy Optimization - Utilizes external and HAN data to determine desired response (e.g. reduce load, shift load, start load, etc.) based on a consumer-configurable profile (e.g. profiles based on various triggers such as occupancy (home/away/vacation), schedule (day/night/weekend), price (low/med/high), demand response requests (voluntary/mandatory))
- Environmental Impact - Calculates environmental impact of current energy consumption (e.g. based on the CO_2 emission profile of a generation portfolio)

Human Machine Interface (HMI) – Most applications will need an HMI in order to provide local user input and/or output. These applications are based on the data type.

- User Input - Provides Consumers with a means to input data into an application (e.g. touch screen, keypad, mobile phone, computer, etc.)
- User Output - Provides an Application with a means to output data to the Consumer (e.g. message, browser, mobile phone, display, etc.)

Communications is one of the most challenging categories for the HAN. The OpenHAN TF has identified communications criteria for commissioning and control.

Commissioning is the network process of adding a HAN Device on the HAN to allow the device to communicate with other devices. This process is decoupled from the Registration and Enrollment processes. Commissioning involves the following:

- Network scanning – Identifying candidate networks the device could elect to join.
- Network selection – Selection of the network the device will attempt to join
- Network admission – Inclusion of the device onto one of the candidate networks. This may include providing a network key.
- Network configuration - Establishing network specific device parameters (e.g. network ID, initial path, bindings)

Control of a node is enabled by the platform specific technology and it involves:

- Self-Organization – network must be self-forming and self-organizing
- Optimization - Path selection
- Mitigation - Ability to adapt and work in response to interference or range constraints

Security goes hand-in-hand with Communications. Introduction of a communications technology for the home requires enhanced security in the ESI to protect the overall HAN, communication between HAN Devices, Service Provider systems, and Consumer privacy. The OpenHAN TF expects the UCAIug AMI Security Task Force to address the security requirements of the Utility AMI system in greater detail. However, due to the importance of this category, the OpenHAN TF addresses specific security criteria that pertain to the ESI (e.g. Utility ESI, other ESI). The security categories addressed are: Access Control and Confidentiality, Registration, Enrollment, Integrity, and Accountability.

Access Controls and Confidentiality address levels of data protection based on data type. All data will have some level of access control, but there are various requirements associated with data-at-rest and data-in-transit based on data type.

- Public Controls (low robustness) - Protection methods for publicly available information (e.g. conservation messages, etc.)
- Private Controls (medium robustness) - Protection methods for confidential or sensitive data (e.g. Consumer usage)
- Utility Controls (high robustness) - Protection methods for Utility accountable data (e.g. load control, other premises metering data)

Registration is the network process to authenticate and authorize HAN Device participation with an ESI. Once a HAN Device is Commissioned. it is part of the network. However, the device must go through the Registration process to privately send and receive information with other devices registered to a common ESI. Therefore, Registration involves the following:

- Initialization –The process of making the HAN Device information (e.g. MAC address, security codes, etc.) available to the authentication service utilized by that ESI.

- Authentication – The process of verifying the application / device as a trusted device (i.e. verifies the application's / device's identity). This may include mutual authentication.
- Correlation – Creates a trust relationship between the HAN Device and the ESI (e.g. exchanging information based on security credentials)
- Authorization – Governs rights granted to devices.
- De-register – the process of removing a device that has been Registered (i.e. removing the correlation and authorization)

Enrollment is the process by which a Consumer enrolls a HAN Device in a Service Provider's program (e.g. demand response, energy management, pre-pay, PEV programs, distributed generation, pricing, messaging, etc.) and gives certain rights to the Service Provider to communicate with their HAN Device.

Integrity preserves the HAN operating environment through:

- Resistance – Methods which prevent changes to the application or application's data (e.g. tamper and compromise resistance)
- Recovery – Restores an application or the application's data to a previous or desired state (e.g. reloading an application, resending corrupted communications)

Accountability will allow for monitoring malicious activities through:

- Audit – Applications log detected compromise attempts
- Non-repudiation – Applications and application operators are responsible for actions (e.g. can not deny receipt or response)

Performance requirements ensure applications or other factors do not limit the performance of the system. Since the HAN SRS is written at a platform-independent level, these criteria are higher level than the others found in this document. The requirements associated with these criteria are also less detailed than others for the same reason that, depending on technology selection, their performance requirements will differ. Performance of the system is usually dependent on the following:

Availability - The applications and devices are consistently reachable

Reliability - The applications and devices are designed and manufactured to be durable and resilient

Maintainability - The applications and devices are designed to be easily diagnosed and managed

Scalability - The system supports a reasonable amount of growth in applications and devices

Upgradeability - The applications and devices have a reasonable amount of remote upgradeability (e.g. patches, updates, enhancements)

Quality - The applications and devices will perform as advertised

Latency - The applications will respond in an appropriate amount of time

Operations, Maintenance and Logistics criteria address the challenges around deploying HAN Devices in a new market segment. The OpenHAN TF's goal is to make the design, maintenance, and operation of the system as easy and cost effective as possible while not compromising security and performance. There are many activities involved in reaching this goal:

Manufacturing and Distribution - Vendor's pre-installation activities

- Pre-commissioning - Depot level configuration setting
- Application configuration - Any required Service Provider specific configurations or applications
- Labeling - compliance and standards labeling
- Purchasing - Supports multiple distribution channels (e.g. retail, wholesale, Service Provider, etc.)

Installation - Physical placement of the device

- Documentation - Installation materials and manuals (e.g. how to install, how to operate, how to commission, etc.)
- Support Systems - Installation support systems including web support, help line, other third party systems

Manage, Maintain

- Alarming and logging - Event driven notifications
- Testing - System and device testing
- Device reset - Resets the device to the installation state
- Monitoring – device and application heartbeat

3.3 Requirements Assumptions

This section documents the assumptions on which the requirements are based. It will be helpful to refer back to these throughout the rest of the specification.

1. Service Providers are granted access rights to HAN Devices in a Consumer premises by the Consumer.
2. Service Providers expect vendor differentiation and innovation in the marketplace.
3. Assume orderly shutdown of operations during Control Signal execution (e.g. shutdown could be delayed until current process completes, shutdown is such that it does not compromise safety systems built into HAN Devices, etc.).
4. HAN Device is responsible for validating the source of all communication.
5. EMS may proxy as the controller (e.g. Utility, Service Provider, Consumer, etc.).
6. EMS devices are viewed as aggregating functions within the system and may aggregate data from multiple sources.
7. Rate and consumption information can pass from an ESI (e.g. Utility ESI, or other ESI) to the Energy Cost application.
8. Energy Cost applications may, but are not required to, reconcile costs displayed on HAN Devices with bills generated by a Service Provider billing system.

There are other elements associated with billing and revenue-grade metering that are outside the scope of these requirements (e.g. revenue-grade certification, Utility rate recovery).

9. The HAN provides secure communication with multiple HAN Devices and different device types to support scalability and growth.
10. The HAN Device may have default configurations that allow the Consumer to use the HAN Device following installation and Commissioning to the greatest degree possible (e.g. smart appliance or PCT operates even if it is not Registered or Enrolled in a program, etc.).
11. Authorized users (e.g. Utility, Consumer, Service Provider, etc.) shall be provided two-way access to HAN Devices Enrolled in Service Provider programs.
12. Utility ESI is assumed to be a secure logical device on the Utility AMI system.

The requirements listed in these sections are not prioritized by criticality or sophistication and include some fairly advanced functional capabilities that may be beyond the current state of the market. This is intentional.

3.4 Application Requirements

Application requirements are the heart of HAN interactions and define what HAN Devices do. These applications include: Control, Measurement & Monitoring, Processes, and Human-to-machine interfaces and are broadly described here. Other functions and programs supported by applications include: demand response, messaging, bi-directional consumption sharing (metering data) and price delivery, off-the-shelf HAN Device installation and configuration by Consumers, multi-dwelling unit (MDU) deployments, consumer energy conservation, control, etc.

3.4.1 Control

Control applications respond to Control Signals, which are structured messages sent from an authorized party (e.g. Utility, Service Provider, EMS, Consumer) requesting operational state change of a HAN Device. This includes traditional direct load control commands (e.g. on/off, set duty cycle) and more advanced demand response commands where price or other data points may trigger a HAN Device to limit its energy consumption. HAN Devices will respond within the operation of their control systems and algorithms. This response may be based on consumer preferences, internal safety systems, preconfigured thresholds, time-based values, and/or adaptive algorithms that may be present in the HAN Device, EMS, and Service Provider solutions.

Requirements:

App.Control.1 HAN Device shall accept Control Signals from one or more authorized parties (e.g. Utility, Service Provider, EMS, Consumer).

App.Control.2 HAN Device shall limit or reduce energy consumption in response to Control Signal receipt.

App.Control.3 HAN Device shall resume previous operational state (as appropriate) following receipt of Control Signal that cancels, expires, or overrides a previous Control Signal in effect.

App.Control.4 HAN Device shall acknowledge receipt of Control Signal when requested.

App.Control.5 HAN Device shall acknowledge execution of Control Signal, when requested.

App.Control.6 HAN Device shall acknowledge execution failure of Control Signal (i.e. exceptions).

App.Control.7 HAN Device shall communicate any Consumer or device initiated overrides or delays in response (e.g. all events in a program, specific demand response event, all events in a specific time period, partial overrides, etc.).

App.Control.8 HAN Device shall implement its response to a Control Signal at a specified future time as set forth in the Control Signal.

App.Control.9 HAN Device shall resume previous operational state (as appropriate) following expiration of a Control Signal.

App.Control.10 HAN Device shall support randomization of scheduled Control Signal start and stop times to prevent unnecessary stress on the electric grid.

1

Table 3: Control Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	HAN Device shall accept Control Signals from one or more authorized parties (e.g. Utility, Service Provider, EMS, Consumer).	NA	NA	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA
2	HAN Device shall limit or reduce energy consumption in response to Control Signal receipt.	NA	NA	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA
3	HAN Device shall resume previous operational state (as appropriate) following receipt of Control Signal that cancels, expires, or overrides a previous Control Signal in effect	NA	NA	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA
4	HAN Device shall acknowledge receipt of Control Signal, when requested.	NA	NA	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA
5	HAN Device shall acknowledge execution of Control Signal, when requested.	NA	NA	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA
6	HAN Device shall acknowledge execution failure of Control Signal (i.e., exceptions).	NA	NA	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA
7	HAN Device shall communicate any Consumer or device-initiated overrides or delays in response (e.g. all events in a program, specific demand response event, all events in a specific time period, partial overrides, etc.).	NA	NA	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA

Table 3: Control Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
8	HAN Device shall implement its response to a Control Signal at a specified future time as set forth in the Control Signal.	NA	NA	BF	NA	BF	O	NA	NA	O	BF	BF	NA
9	HAN Device shall resume previous operational state (as appropriate) following expiration of a Control Signal.	NA	NA	BF	NA	BF	O	NA	NA	O	BF	BF	NA
10	HAN Device shall support randomization of scheduled Control Signal start and stop times to prevent unnecessary stress on the electric grid.	NA	NA	BF	NA	BF	O	NA	NA	O	BF	BF	NA

1

3.4.2 Measurement and Monitoring

Measurement and monitoring applications provide data and status from HAN Devices. These are functional requirements on the device. They do not speak to the organization of the system. The applications covered are DER (e.g. solar, fuel cell, wind), metering of devices within the premises (e.g. Consumer PEV), monitoring of local conditions (e.g. temperature, humidity, time, airflow, ambient light level, motion), and monitoring of a device's state. These applications provide input to the HAN system and enable processing and action based upon that input. Appropriate levels of security to protect consumer privacy must be observed by the receiving entity of each of these data.

Requirements:

App.Measure.1 HAN Device shall measure instantaneous demand (e.g. W).

App.Measure.2 HAN Device shall measure accumulated consumption (e.g. Wh) for a variety of time periods (e.g. 15 minutes, hour, day, month, configurable period, year, etc.) and price periods (e.g. TOU-Peak period, TOU-Shoulder period, CPP period, etc.).

App.Measure.3 HAN Device shall measure accumulated production (e.g. Wh) for a variety of time periods (e.g. 15 minutes, hour, day, month, configurable period, year, etc.) and price periods (e.g. TOU-Peak period, TOU-Shoulder period, CPP period, etc.).

App.Measure.4 HAN Device shall measure consumption per interval (e.g. Wh, BTU, HCF).

App.Measure.5 HAN Device shall measure production per interval (e.g. Wh).

App.Measure.6 HAN Device shall store interval measurements (e.g. 30 days of interval reads).

App.Measure.7 HAN Device shall allow interval configuration (e.g. 15 minutes).

App.Measure.8 HAN Device shall monitor energy state (e.g. state of charge, Watt-hour).

App.Measure.9 HAN Device shall measure available capacity (e.g. Watts, Volt-Amps).

App.Measure.10 HAN Device shall monitor the end-device state (e.g. operational, stand-by, maintenance).

App.Measure.11 HAN Device shall measure power quality (e.g. frequency, neutral voltage, harmonic content).

App.Measure.12 HAN Device shall monitor environmental state (e.g. temperature, motion, wind, etc.).

App.Measure.13 HAN Device shall monitor the operational mode of other HAN Devices (e.g. duty cycle, charging, discharging, etc.).

App.Measure.14 HAN Device shall support multiple measurement standards (e.g. metric, US, Imperial) for energy applications.

App.Measure.15 HAN Device shall measure Peak Demand per time of use/Critical Peak Pricing period and Peak Demand per configurable period.

App.Measure.16 HAN Device shall support other metrology information as provided from the meter (e.g. volts, amps, VAR, power factor, etc.).

App.Measure.17 HAN Device shall support temperature information.

App.Measure.18 HAN Device shall support billing Information (e.g. rate label, Service Provider name or ID, etc).

App.Measure.19 HAN Device shall provide the ability to measure discrete HAN Device loads for specific Service Provider programs (i.e. billing PEV charging at preferential rates).

App.Measure.20 HAN Device shall measure or monitor and display status indicators related to pricing and billing status (e.g. current TOU period, current Block Pricing Tier, CPP Event, etc.).

App.Measure.21 HAN Device shall make its measurements available to other Registered HAN devices.

1

Table 4: Measurement and Monitoring Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	HAN Device shall measure instantaneous demand (e.g. W).	NA	NA	NA	NA	O	NA	BF	BF	O	NA	BF	BF
2	HAN Device shall measure accumulated consumption (e.g. Wh) for a variety of time periods (e.g. 15 minutes, hour, day, month, configurable period, year, etc.) and price periods (e.g. TOU-Peak period, TOU-Shoulder period, CPP period, etc.).	NA	NA	NA	NA	O	NA	BF	BF	O	NA	O	O
3	HAN Device shall measure accumulated production (e.g. Wh) for a variety of time periods (e.g. 15 minutes, hour, day, month, configurable period, year, etc.) and price periods (e.g. TOU-Peak period, TOU-Shoulder period, CPP period, etc.).	NA	NA	NA	NA	O	NA	BF	BF	O	NA	O	O
4	HAN Device shall measure consumption per interval (e.g. Wh, BTU, CCF, HCF).	NA	NA	NA	NA	O	NA	BF	BF	O	NA	O	O
5	HAN Device shall measure production per interval (e.g. Wh).	NA	NA	NA	NA	O	NA	BF	BF	O	NA	O	O
6	HAN Device shall store interval measurements (e.g. 30 days of interval reads).	NA	NA	NA	O	O	NA	BF	BF	O	NA	O	O
7	HAN Device shall allow interval configuration (e.g. 15 Minutes).	NA	NA	NA	O	O	NA	O	O	O	NA	O	O

Table 4: Measurement and Monitoring Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
8	HAN Device shall monitor energy state (e.g. state of charge, Watt-hour).	NA	NA	O	O	O	O	NA	NA	O	O	BF	O
9	HAN Device shall measure available capacity (e.g. Watts, Volt-Amps).	NA	NA	NA	NA	O	NA	NA	NA	O	NA	O	O
10	HAN Device shall monitor the end-device state (e.g. operational, stand-by, maintenance).	NA	NA	BF	NA	O	BF	NA	NA	O	O	O	NA
11	HAN Device shall measure power quality (e.g. frequency, neutral voltage, harmonic content).	NA	NA	NA	NA	NA	NA	O	NA	O	NA	O	O
12	HAN Device shall monitor environmental state (e.g. temperature, motion, wind, etc.).	NA	NA	BF	NA	O	NA	NA	NA	O	NA	O	NA
13	HAN Device shall monitor the operational mode of other HAN Devices (e.g. duty cycle, charging, discharging, etc.).	NA	NA	NA	NA	BF	NA	NA	NA	O	NA	NA	NA
14	HAN Device shall support multiple measurement standards (e.g. metric, US, Imperial) for energy applications.	NA	NA	NA	O	O	NA	NA	NA	O	NA	NA	NA
15	HAN Device shall measure Peak Demand per time of use (e.g. Critical Peak Pricing period, Peak Demand per configurable period, charging profile, etc.).	NA	NA	NA	O	O	NA	O	O	O	NA	O	O
16	HAN Device shall support other metrology information as provided from the meter (e.g. Volts, Amps, VAr, Power Factor, etc.)	NA	NA	NA	O	O	NA	NA	NA	O	NA	NA	NA

Table 4: Measurement and Monitoring Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
17	HAN Device shall support temperature information.	NA	NA	BF	NA	O	NA	NA	NA	O	NA	O	NA
18	HAN Device shall support billing Information (e.g. rate label, Service Provider name or ID, etc)	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	NA
19	HAN Device shall provide the ability to measure discrete HAN Device loads for specific Service Provider programs, (i.e. billing PEV charging at preferential rates).	NA	NA	NA	NA	O	NA	NA	NA	O	NA	O	BF
20	HAN Device shall measure or monitor and display status indicators related to pricing and billing status (e.g. current TOU period, current Block Pricing Tier, CPP Event, etc.)	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	NA
21	HAN Device shall make its measurements available to other Registered HAN devices.	NA	NA	NA	NA	O	NA	BF	O	NA	NA	O	O

1

3.4.3 Processing

Processing are applications that consume, process, and act on external data (e.g. data coming from outside the HAN, rate, billing, etc.) and internal data (e.g. data from within the HAN environment). These applications accept data from external systems and HAN measurement & monitoring applications. In general, these applications have a higher level of complexity and cost.

Requirements:

App.Process.1 The application shall calculate a HAN Device's cost of accumulated energy consumption as monetary value (e.g. $/kWh * accumulated kWh = $).

App.Process.2 The application shall calculate a HAN Device's energy cost of instantaneous power consumption as a monetary value per time interval (e.g. $/Wh * instantaneous W= $/hr).

App.Process.3 The application shall calculate a HAN Device's cost for Dynamic Energy rates for the appropriate time interval.

App.Process.4 The application shall calculate a HAN Device's energy cost for rate tiers/energy blocks.

App.Process.5 The application shall calculate a HAN Device's energy cost for Time-of-Use (TOU) energy rates.

App.Process.6 The application shall calculate a HAN Device's cost for Critical Peak Pricing (CPP).

App.Process.7 The application shall calculate a HAN Device's cost for capacity billing rates.

App.Process.8 The application shall calculate costs for other billing determinants (e.g. monthly consumer charges, taxes & franchise fee, surcharges, discounts, ratcheted demand, bond charges).

App.Process.9 The application shall accept aggregated consumption, billing, and rate information from user-configurable sources (e.g. AMI System, EMS, HMI, etc.).

App.Process.10 The application shall calculate and forecast a HAN Device's consumption based on user-defined parameters (e.g. estimated kWh/month).

App.Process.11 The application shall calculate and forecast a HAN Device's production based on user-defined parameters (e.g. estimated kWh/month).

App.Process.12 The application shall forecast a HAN Device's estimated cost calculation based on user-defined parameters (e.g. monthly consumption at current rate/usage).

App.Process.13 The application shall calculate a HAN Device's consumption based on user-defined parameters (e.g. historical reporting).

App.Process.14 The application shall calculate and/or predict a HAN Device's environmental impact based on user-defined parameters (e.g. historical carbon footprint, forecasted carbon credits earned).

App.Process.15 The application shall supply a method for local billing resolution and true-up to approximate Service Provider billing amounts (e.g. orphaned billing charge, consumption debits/credits, manual entry of surcharges, etc).

App.Process.16 The application shall manage and/or make suggestions related to energy consumption and costs for load devices under its control (e.g. PCT, lights, PEV, pool pump, smart appliances, etc.). This can be based on the consumer's rate structure (e.g. CPP, TOU, real-time pricing, demand rates, etc.), Service Provider program parameters (e.g. demand response, etc.), and Consumer-defined parameters (e.g. demand limit, PCT thresholds, lighting settings, pool pump cycling, PEV charging schedule, household schedule, payment objective, etc.).

App.Process.17 The application shall calculate a HAN Device's relative performance (e.g. comparison can be based on historical data, baseline at install, manufacturer's parameters, industry/governmental guidelines, other devices, other premises).

App.Process.18 The application shall calculate available load for demand reduction based on user-defined parameters (e.g. percentage of load available for various response scenarios, minimum load, maximum load, etc).

App.Process.19 The application shall support multiple rate structures (e.g. time-of-use, inclining block tiers, critical peak pricing events, Peak Time Rebate, Real Time Pricing, all combinations thereof, etc.).

App.Process.20 The application shall send an acknowledgement of receipt of message only upon request.

App.Process.21 HAN Device shall have the ability to be assigned to a group.

App.Process.22 The application shall support comparisons of energy consumption and cost information to externally supplied values (e.g. average user comparisons, comparisons with a baseline, track progress toward a target, etc.).

App.Process.23 The application shall support configurable periods.

App.Process.24 The application shall make available Peak Demand per time of use /Critical Peak Pricing period and Peak Demand per configurable period (e.g. EMS, IHD, etc.).

App.Process.25 The application shall provide method for communicating constraints when the HAN Device (i.e. a demand

response asset) is available for load shed (e.g. time of day schedule constraints, black out dates, maximum consecutive days of participation, maximum duration of demand response event participation, minimum duration of demand response event participation, maximum number of times per day demand response resource may be called, minimum advanced notification necessary, etc.).

App Process.26 The application shall calculate the load deferred or overridden (i.e. opted-out) by the Consumer during a demand response event**.**

App.Process.27 The application shall communicate effective starting date and time when the HAN Device is expected to comply with the demand response obligation.

App.Process.28 The application shall accept a decimal representation of the expected duration of the demand response event with integers representing hours and decimal positions representing fraction of hours (e.g. 1.5 indicates duration of 1 hour and 30 minutes from the effective-start-date-time).

App.Process.29 The application shall accept a unique identifier for the demand response event (e.g. a URI in accordance with http://www.w3.org/TR/uri-clarification/#uri-schemes) to manage the most recent information.

App.Process.30 The application shall respond to a price for the duration the price is valid. The prices may be published on a frequency interval.

App.Process.31 The application shall accept a price expressed in decimal notation with a precision up to 6 decimal places. Prices may be either positive or negative.

App.Process.32 The application shall accept the unit of measure for which the price pertains. Must be compliant with the International System of Units as defined by NIST SP 330, ref: http://physics.nist.gov/Pubs/SP330/sp330.pdf (e.g. kWh, MWh).

App.Process.33 The application shall send any override (i.e. out-out) messages to the Service Provider, when an override (i.e. opt-out) occurs before or during a demand response event.

App.Process.34 The application shall determine the device operation mode or state using both a price and relative price signal (e.g. low, medium, high, critical, etc.).

App.Process.35 The application shall inform (e.g. display, text message, email, etc.) the authorized user (e.g. Consumer, Service Provider, etc.) of the initiation and termination of a charging session (e.g. PEV, etc.).

App.Process.36 The application shall calculate and make available either locally or remotely the current state of the storage (e.g. PEV

battery charge level, etc.) in a user configured format (e.g. travel miles available, kWh available, etc.).

App.Process.37 The application shall provide methods to support negotiation of an energy request with ESI (e.g. for PEV charging purposes). This might include requested charge amount (in KWh) requested charge time, charging start and end time(s), available charge amount, charging rate, etc.

App.Process.38 The application shall accumulate consumption, production, and cost and measure it against user-defined thresholds (e.g. if aggregated consumption reaches a certain level an alert is generated, PEV is charged for 20 miles of driving, etc.).

App.Process.39 The application shall support on-board PEV calculations (e.g. cost per distance). [Note: consumer may want this information displayed on another HAN Device, (e.g. EMS); EMS may want to request this information so consumer can make charging decisions.]

App.Process.40 The application shall respond appropriately to changes in events (e.g. demand response, PEV charging, etc.) and ensure execution of the most recent information.

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Table 5: Process Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	The application shall calculate a HAN Device's cost of accumulated energy consumption as monetary value (e.g. $/kWh * accumulated kWh = $).	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	O
2	The application shall calculate a HAN Device's energy cost of instantaneous power consumption as a monetary value per time interval, (e.g. $/Wh * instantaneous W= $/hr).	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	O
3	The application shall calculate a HAN Device's cost for Dynamic Energy rates for the appropriate time interval.	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	O
4	The application shall calculate a HAN Device's energy cost for rate tiers/energy blocks.	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	O
5	The application shall calculate a HAN Device's energy cost for Time-of-Use (TOU) energy rates.	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	O
6	The application shall calculate a HAN Device's cost for Critical Peak Pricing (CPP).	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	O
7	The application shall calculate a HAN Device's cost for capacity billing rates.	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	O

Table 5: Process Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
8	The application shall calculate costs for other billing determinants (e.g. monthly Consumer charges, taxes & franchise fee, surcharges, discounts, ratcheted demand, bond charges).	NA	NA	NA	O	O	NA	NA	NA	O	NA	NA	O
9	The application shall accept aggregated consumption, billing, and rate information from user-configurable sources (e.g. AMI System, EMS, HMI, etc,).	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	O
10	The application shall calculate and forecast a HAN Device's consumption based on user-defined parameters (e.g. estimated kWh/month).	NA	NA	NA	O	O	NA	NA	NA	O	NA	BF	O
11	The application shall calculate and forecast a HAN Device's production based on user-defined parameters (e.g. estimated kWh/month).	NA	NA	NA	O	O	NA	NA	NA	O	NA	BF	O
12	The application shall forecast a HAN Device's estimated cost calculation based on user-defined parameters (e.g. monthly consumption at current rate/usage).	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	O
13	The application shall calculate a HAN Device's consumption based on user-defined parameters (e.g. historical reporting).	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	O

Table 5: Process Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
14	The application shall calculate and/or predict a HAN Device's environmental impact based on user-defined parameters (e.g. historical carbon footprint, forecasted carbon credits earned).	NA	NA	NA	O	O	NA	NA	NA	O	NA	O	O
15	The application shall supply a method for local billing resolution and true-up to approximate Service Provider billing amounts (e.g. orphaned billing charge, consumption debits/credits, manual entry of surcharges, etc.).	NA	NA	NA	O	O	NA	NA	NA	O	NA	NA	O
16	The application shall manage and/or make suggestions related to energy consumption and costs for load devices under its control (e.g. PCT, lights, PEV, pool pump, smart appliances, etc.). This can be based on the consumer's rate structure (e.g. CPP, TOU, real-time pricing, demand rates, etc.), Service Provider program parameters (e.g. demand response, etc.), and Consumer-defined parameters (e.g. demand limit, PCT thresholds, lighting settings, pool pump cycling, PEV charging schedule, household schedule, payment objective, etc.).	NA	NA	NA	O	O	NA	NA	NA	NA	NA	O	NA

Table 5: Process Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
17	The application shall calculate a HAN Device's relative performance (e.g. comparison can be based on historical data, baseline at install, manufacturer's parameters, industry/governmental guidelines, other devices, other premises).	NA	NA	NA	NA	O	NA	NA	NA	O	NA	O	NA
18	The application shall calculate available load for demand reduction based on user-defined parameters (e.g. percentage of load available for various response scenarios, minimum load, maximum load, etc).	NA	NA	O	NA	O	O	NA	NA	O	NA	BF	O
19	The application shall support multiple rate structures (e.g. time-of-use, inclining block tiers, critical peak pricing events, Peak Time Rebate, Real Time Pricing, all combinations thereof, etc.).	NA	NA	NA	O	O	NA	O	NA	O	O	BF	NA
20	The application shall send an acknowledgement of receipt of message only upon request.	BF	BF	O	O	O	O	NA	NA	O	O	BF	O
21	HAN Device shall have the ability to be assigned to a group.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
22	The application shall support comparisons of energy consumption and cost information to externally supplied values (e.g. average user comparisons, comparisons with a baseline, track progress toward a target, etc.).	NA	NA	NA	O	O	NA	NA	NA	NA	NA	O	NA

Table 5: Process Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
23	The application shall support configurable periods.	BF	BF	BF	BF	BF	BF	NA	NA	BF	O	BF	NA
24	The application shall make available Peak Demand per time of use /Critical Peak Pricing period and Peak Demand per configurable period (e.g. EMS, IHD, etc.).	NA	NA	O	O	O	NA	NA	NA	O	O	BF	NA
25	The application shall provide method for communicating constraints when the HAN Device (i.e. a demand response asset) is available for load shed (e.g. time of day schedule constraints, black out dates, maximum consecutive days of participation, maximum duration of demand response event participation, minimum duration of demand response event participation, maximum number of times per day demand response resource may be called, minimum advanced notification necessary, etc.).	NA	NA	O	NA	O	O	NA	NA	O	O	BF	NA
26	Application shall calculate the load deferred or overridden (i.e. opted-out) by the Consumer during a demand response event.	NA	NA	O	NA	O	O	NA	NA	O	O	O	NA
27	The application shall communicate effective starting date and time when the HAN Device is expected to comply with the demand response obligation.	NA	NA	O	NA	O	O	NA	NA	O	O	BF	NA

Table 5: Process Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
28	The application shall accept a decimal representation of the expected duration of the demand response event with integers representing hours and decimal positions representing fraction of hours (e.g. 1.5 indicates a duration of 1 hour and 30 minutes from the effective-start-date-time).	NA	NA	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA
29	The application shall accept a unique identifier for the demand response event (e.g. a URI in accordance with http://www.w3.org/TR/uri-clarification/#uri-schemes) to manage the most recent information.	NA	NA	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA
30	The application shall respond to a price for the duration the price is valid. The prices may be published on a frequency interval.	NA	NA	BF	O	BF	BF	NA	NA	BF	BF	BF	NA
31	The application shall accept a price expressed in decimal notation with a precision up to 6 decimal places. Prices may be either positive or negative.	NA	NA	BF	BF	BF	BF	NA	NA	BF	BF	BF	NA
32	The application shall accept the unit of measure for which the price pertains. Must be compliant with the International System of Units as defined by NIST SP 330, ref: http://physics.nist.gov/Pubs/SP330/sp330.pdf (e.g. kWh, MWh).	NA	NA	BF	BF	BF	BF	NA	NA	BF	BF	BF	NA

Table 5: Process Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
33	The application shall send any override (i.e. opt-out) messages to the Service Provider, when an override (i.e. opt-out) occurs before or during a demand response event.	BF	BF	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA
34	The application shall determine the device operation mode or state using both a price and relative price signal (e.g. low, medium, high, critical, etc.).	NA	NA	O	NA	O	O	NA	NA	BF	O	BF	NA
35	The application shall inform (e.g. display, text message, email, etc.) the authorized user (e.g. Consumer, Service Provider, etc.) of the initiation and termination of a charging session (e.g. PEV, etc.)	NA	NA	NA	O	O	NA	NA	NA	NA	O	O	NA
36	The application shall calculate and make available either locally or remotely the current state of the storage (e.g. PEV battery charge level, etc.) in a user configured format (e.g. travel miles available, kWh available, etc.).	NA	NA	NA	O	O	NA	NA	NA	NA	O	BF	NA

Table 5: Process Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
37	The application shall provide methods to support negotiation of an energy request with ESI (e.g. for PEV charging purposes). This might include requested charge amount (in KWh) requested charge time, charging start and end time(s), available charge amount, charging rate, etc.	NA	NA	O	NA	O	O	NA	NA	O	O	BF	NA
38	The application shall accumulate consumption, production, and cost and measure it against user-defined thresholds (e.g. if aggregated consumption reaches a certain level an alert is generated, PEV is charged for 20 miles of driving, etc.).	NA	NA	NA	O	O	NA	NA	NA	NA	NA	O	NA
39	The application shall support on-board PEV calculations (e.g. cost per distance). [Note: consumer may want this information displayed on another HAN Device, (e.g. EMS); EMS may want to request this information so consumer can make charging decisions].	NA	NA	NA	NA	O	NA	NA	NA	NA	O	O	NA
40	The application shall respond appropriately to changes in events (e.g. demand response, PEV charging, etc.) and ensure execution of the most recent information.	NA	NA	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA

3.4.4 Human-Machine Interface

Human-Machine Interfaces are applications that provide local user input and/or output. These applications may be limited and may be depend upon the device type. They provide a method for users to interact with the HAN, enter preferences, configure the HAN and its devices, and obtain useful information from the HAN and its devices.

Requirements:

App.HMI.1 HAN Device shall provide visual indicators which indicate operational state (e.g. commissioned, registered, event status, device state, etc.).

App.HMI.2 HAN Device shall provide a power cycle input, which reboots the device.

App.HMI.3 HAN Device shall provide abilities for the Consumer to reset the HAN Device to a default or pre-installation state and to erase all Consumer information (e.g. usage, billing, pricing, etc.).

App.HMI.4 HAN Device shall provide an alphanumeric display which indicates operational state (e.g. LCD screen).

App.HMI.5 HAN Device shall provide non-visual sensory feedback (e.g. motion, vibration, audible).

App.HMI.6 HAN Device shall provide access for individuals with disabilities (e. g. visual, auditory, mobility, cognitive and other disabilities).

App.HMI.7 HAN Device shall provide a user-configurable display.

App.HMI.8 HAN Device shall accept user configurations.

App.HMI.9 HAN Device shall accept user display preferences (e.g. Celsius/Fahrenheit, color, language, currency, decimal places, etc.).

App.HMI.10 HAN Device shall provide alarm notifications (e.g. price threshold, event messages).

App.HMI.11 HAN Device shall accept and display configuration of Service Provider data source (e.g. ESI, other HAN Devices).

App.HMI.12 HAN Device shall display application-specific information (e.g. cost, consumption, environmental impact, payment credit, remaining account credit).

App.HMI.13 HAN Device shall accept application-specific configurations (e.g. preconfigured periods (e.g. hour, day, week)), configurable periods (e.g. interval length, TOU period), variable periods (e.g. Critical Peak Price period).

App.HMI.14 For battery-powered devices, HAN Device shall provide a battery life indicator.

App.HMI.15 HAN Device shall accept payment data from the Consumer.

App.HMI.16 The application shall support multiple languages and shall accept user preference of language.

App.HMI.17 The HAN Device shall display a description of the demand response event that is occurring.

App.HMI.18 The HAN device shall display information using units that are common to the Consumer in the Consumer's locale.

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Table 6: Human Machine Interface Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	HAN Device shall provide visual indicators which indicate operational state (e.g. commissioned, registered, event status, device state, etc.).	NA	NA	O	O	O	NA	NA	NA	NA	O	O	NA
2	HAN Device shall provide a power cycle input, which reboots the device.	NA	BF	BF	O	BF	O	NA	NA	O	BF	BF	BF
3	HAN Device shall provide abilities for the Consumer to reset the HAN Device to a default or pre-installation state and to erase all Consumer information (e.g. usage, billing, pricing, etc.).	NA	BF	BF	BF	BF	BF	NA	NA	BF	BF	BF	BF
4	HAN Device shall provide an alphanumeric display which indicates operational state (e.g. LCD screen).	NA	NA	BF	BF	O	NA	NA	NA	O	O	O	BF
5	HAN Device shall provide non-visual sensory feedback (e.g. motion, vibration, audible).	NA	NA	O	O	O	O	NA	NA	O	O	O	NA
6	HAN Device shall provide access for individuals with disabilities (e.g. visual, auditory, mobility, cognitive and other disabilities).	NA	NA	O	O	O	O	NA	NA	O	O	O	NA
7	HAN Device shall provide a user-configurable display.	NA	NA	O	O	O	O	NA	NA	O	O	O	NA
8	HAN Device shall accept user configurations.	NA	NA	O	O	O	O	NA	NA	O	O	BF	O

Table 6: Human Machine Interface Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
9	HAN Device shall accept user display preferences (e.g. Celsius/Fahrenheit, color, language, currency, decimal places, etc.).	NA	NA	O	O	O	O	NA	NA	O	O	BF	O
10	HAN Device shall provide alarm notifications (e.g. price threshold, event messages).	NA	NA	O	O	O	O	NA	NA	O	O	O	NA
11	HAN Device shall accept and display configuration of Service Provider data source (e.g. ESI, other HAN Devices).	NA	NA	O	O	O	O	NA	NA	O	O	O	O
12	HAN Device shall display application-specific information (e.g. cost, consumption, environmental impact, payment credit, remaining account credit).	NA	NA	O	BF	O	O	NA	NA	O	O	O	O
13	HAN Device shall accept application-specific configurations (e.g. preconfigured periods (e.g. hour, day, week)), configurable periods (e.g. interval length, TOU period), variable periods (e.g. Critical Peak Price period).	NA	NA	O	O	O	BF	NA	NA	O	BF	BF	BF
14	For battery-powered devices, HAN Device shall provide a battery life indicator.	NA	NA	O	O	O	NA	NA	O	NA	NA	BF	NA
15	HAN Device shall accept payment data from the Consumer.	NA	NA	NA	O	O	NA	NA	NA	NA	O	O	NA
16	HAN Device shall support multiple languages and shall accept user preference of language.	NA	NA	O	O	O	NA	NA	NA	NA	O	BF	NA

Table 6: Human Machine Interface Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
17	The HAN Device shall display a description of the demand response event that is occurring	NA	NA	O	O	O	O	NA	NA	O	O	O	NA
18	The HAN Device shall display information using units that are common to the Consumer in the Consumer's locale.	NA	NA	BF	BF	O	NA	NA	NA	O	O	BF	NA

1

3.5 Communication Requirements

Communication requirements of the HAN SRS are designed to provide reliable message transmissions between the authorized parties (e.g. Utility, Service Provider, EMS, etc.) and the consumer's HAN Devices. These requirements cover Commissioning and Control. Commissioning requirements describe how a new HAN Device is added to the communication network. Control requirements detail how the communication network and HAN Device work together to maintain a reliable communication network.

3.5.1 Commissioning

Commissioning is defined as the network process of identifying and adding a node on the HAN with the expectation that the system is self-organizing (i.e., initial communication path configuration). This process is decoupled from Registration and Enrollment.

Requirements:

Comm.Commission.1 HAN Device shall accept network configuration data which allows for admission to a new or existing network (e.g. network ID, etc.).

Comm.Commission.2 HAN Device shall accept Commissioning configuration data from the manufacturer.

Comm.Commission.3 When a HAN Device is triggered (e.g. Power-on, button, etc.), HAN Device shall be capable of providing the HAN with device-specific information (e.g. device ID, device type, networking details, network ID, gateway ID, etc.) needed for Commissioning.

Comm.Commission.4 ESI shall acknowledge and HAN Device shall receive the acknowledgment of a successful Commissioning request (i.e., provide acknowledgement to the requesting HAN Device).

Comm.Commission.5 When a HAN Device is communicating with the ESI, HAN Device shall indicate link connectivity.

Comm.Commission.6 HAN Device shall provide notification to the Installer of the Commissioning status (e.g. successful, unsuccessful, in process, etc.).

Comm.Commission.7 HAN Device shall be uniquely identified (e.g. meter number, Service Point Location, customer id, ESI ID, networking details, MAC Address, etc.).

Comm.Commission.8 HAN Device shall support Commissioning to multiple ESIs.

1

Table 7: Commissioning Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	HAN Device shall accept network configuration data which allows for admission to an existing network or the establishment of a new network (e.g. network ID, etc.).	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP
2	HAN Device shall accept Commissioning configuration data from the manufacturer.	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP
3	When a HAN Device is triggered (e.g. Power-on, button, etc.), HAN Device shall be capable of providing the HAN with device-specific information (e.g. device ID, device type, networking details, network ID, gateway ID, etc.) needed for Commissioning.	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP
4	ESI shall acknowledge and HAN Device shall receive the acknowledgment of a successful Commissioning requests (i.e., provide acknowledgement to the requesting HAN Device).	O	O	O	O	O	O	O	O	O	O	O	O
5	When a HAN Device is communicating with the ESI, HAN Device shall indicate link connectivity.	O	O	O	O	O	O	O	O	O	O	O	O

Table 7: Commissioning Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
6	HAN Device shall provide notification to the Installer of the Commissioning status (e.g. successful, unsuccessful, in process, etc.).	O	O	O	O	O	O	O	O	O	O	O	O
7	HAN Device shall be uniquely identified (e.g. meter number, Service Point Location, customer id, ESI ID, networking details, MAC Address, etc.).	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP
8	HAN Device shall support Commissioning to multiple ESIs.	O	O	O	O	O	O	NA	NA	O	O	O	O

3.5.2 Control

Autonomous functions enabled by the platform-specific technology. These requirements speak to the efficient functioning of HAN communications and are intended to provide robust and reliable communication paths in the HAN.

Requirements:

Comm.Control.1 HAN Device shall accept network organization messages from an ESI (e.g. gateway location, routing table, address).

Comm.Control.2 HAN Device shall accept network organization messages from peer devices (e.g. hidden node).

Comm.Control.3 The HAN shall use a reliable communication methodology and have the ability to overcome interference on the communications medium (e.g. channel hopping, channel avoidance, etc.).

Comm.Control.4 HAN Device shall include a data integrity mechanism for all communications (e.g. checksum).

Comm.Control.5 ESI shall have the ability to activate and deactivate its HAN communication.

Comm.Control.6 HAN Device shall have a configurable availability communication (i.e. heartbeat) frequency to an ESI.

Comm.Control.7 The HAN shall support group messaging to HAN Devices.

Comm.Control.8 The HAN shall support multiple communication paths into the premises (e.g. Utility AMI network, public network, internet, other private network, etc.).

Comm.Control.9 The HAN shall support one-way or two-way communication of customer or program specific information and one way communication of public information.

Comm.Control.10 HAN shall support more than one physical layer.

Comm.Control.11 HAN Device shall be able to attach to one or more ESIs, temporarily, habitually, etc. (e.g. PEV mobility, EMS, gateway, etc.).

Comm.Control.12 HAN Device shall have the ability to communicate directly or indirectly with another HAN Device within the HAN (subject to security policies).

Comm.Control.13 HAN Device shall be able to initiate communication with an ESI (e.g. override of event by PCT, etc).

Comm.Control.14 ESI shall support time stamp logging of communication to/from HAN Devices.

Comm.Control.15 The HAN shall support bridging between communications media (e.g. wireless HAN and wired HAN), while maintaining compatibility and security requirements.

Comm.Control.16 The HAN shall support messaging to individual HAN Devices.

Comm.Control.17 The HAN shall support messaging to groups of HAN Devices.

Comm.Control.18 ESI shall resend a message upon failure of a requested confirmation from HAN Device and the HAN Device shall appropriately handle receipt of retries.

Comm.Control.19 ESI shall provide the communication availability (i.e., heartbeat) of the devices that are Registered to it.

Comm.Control.20 HAN Devices shall be individually addressable.

Comm.Control.21 The HAN shall support multiple ESIs.

1

Table 8: Communication Control Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	HAN Device shall accept network organization messages from an ESI (e.g. gateway location, routing table, address).	NA	NA	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP
2	HAN Device shall accept network organization messages from peer devices (e.g. hidden node).	NA	NA	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP
3	The HAN shall use a reliable communication methodology and have the ability to overcome interference on the communications medium (e.g. channel hopping, channel avoidance, etc.).	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP
4	HAN Device shall include a data integrity mechanism for all communications (e.g. checksum)	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP
5	ESI shall have the ability to activate and deactivate its HAN communication.	BF	BF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	HAN Device shall have a configurable availability communication (i.e. heartbeat) frequency to an ESI.	NA	NA	O	O	O	BF	BF	BF	O	BF	BF	BF
7	The HAN shall support group messaging to HAN Devices.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF

Table 8: Communication Control Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
8	The HAN shall support multiple communication paths into the premises (e.g. Utility AMI network, public network, other private network, etc.).	O	O	O	O	O	O	O	O	O	O	O	O
9	The HAN shall support one-way or two-way communication of customer or program specific information and one way communication of public information.	O	O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	HAN Device shall support more than one physical layer.	O	O	O	O	O	O	O	O	O	O	O	O
11	HAN Device shall be able to attach to one or more ESIs, temporarily, habitually, etc. (e.g. PEV mobility, EMS, gateway, etc.).	NA	NA	O	O	O	O	NA	NA	O	O	O	O
12	HAN Device shall have the ability to communicate directly or indirectly with another HAN Device within the HAN (subject to security policies).	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
13	HAN Device shall be able to initiate communication with an ESI (e.g. override of event by PCT, etc).	O	O	O	O	O	O	O	O	O	O	O	O
14	ESI shall support time stamp logging of communication to/from HAN Devices.	BF	BF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 8: Communication Control Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
15	The HAN shall support bridging between communications media (e.g. wireless HAN and wired HAN), while maintaining compatibility and security requirements.	O	O	O	O	O	O	O	O	O	O	O	O
16	The HAN shall support messaging to individual HAN Devices.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
17	The HAN shall support messaging to groups of HAN Devices.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
18	ESI shall resend a message upon failure of a requested confirmation from HAN Device and the HAN Device shall appropriately handle receipt of retries.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
19	ESI shall provide the communication availability (i.e., heartbeat) of the devices that are Registered to it.	BF	BF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20	HAN Devices shall be individually addressable.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
21	The HAN shall support multiple ESIs.	O	O	O	O	O	O	NA	NA	O	O	O	O

3.6 Security Requirements

The HAN SRS security requirements are designed to help ensure that HAN communications are used for their intended purposes. These security requirements help to verify users' identities, maintain user privacy, and assure responsible use. These security requirements are divided into four sections: Access Controls and Confidentiality, Integrity, Accountability, Registration and Enrollment.

3.6.1 Access Controls and Confidentiality

The goal of access control is to prevent the unauthorized use of HAN resources. Access control includes resource control; for example, preventing logon to local HAN Devices. For the purposes of this discussion, access control is not concerned with denying physical access. Access control is applied to an entity based on an identity or an authorization. An identity may represent an actual user, a process with its own identity (e.g. a program making a remote access connection), or a number of users represented by single identity (e.g. role-based access control).

Confidentiality refers to the security services that prevent unauthorized disclosure of data (both stored and communicated). Confidentiality services prevent disclosure of data in transit and data at rest. Confidentiality services also include "anonymity", a service which prevents disclosure of information which leads to the identification of the source or end-user of the information. Because of its role in limiting authorized disclosure of information, confidentiality services are closely linked with access control services.

Requirements:

Security.Access.1 ESI shall provide access control (i.e., logical segmentation) to Service Provider applications, data, and services (e.g. control data, consumer-specific consumption data).

Security.Access.2 HAN Device shall control access to persistent HAN data (data at rest).

Security.Access.3 HAN Device shall provide protection of transmitted HAN data (data in transit).

Security.Access.4 HAN Device shall provide protection of HAN data while being processed (data in processing).

Security.Access.5 HAN Device shall control access to data in accordance with a managed security policy when logically linking one or more networks.

Security.Access.6 ESI shall provide mechanisms to enforce a policy based on least privilege (i.e. explicit authorization) for communications with an ESI.

Security.Access.7 ESI shall have the ability to enforce policy periods (time constraints) for security policy elements for communications with an ESI.

Security.Access.8 HAN Device shall provide methods to query and report access control data settings.

Security.Access.9 HAN Device shall provide protection against known attacks, including but not limited to, replay, man-in-the-middle, delay, spoofing, sequence change, denial of service, and deletion attacks.

Security.Access.10 HAN Device shall implement mechanisms to prevent unintended disclosure of source and originator data to unauthorized parties.

Security.Access.11 HAN Device shall implement controls which limit access to audit information.

Security.Access.12 HAN Device shall support cryptographically verifiable operations that provide confidentiality and integrity.

Security.Access.13 The application shall provide a means for authorized users to configure HAN Devices to communicate with one or more ESIs.

Security.Access.14 The HAN shall follow NIST SP 800-57, Recommendation for Key Management[22].

Security.Access.15 Utility ESI and AMI Meter shall comply with the AMI Security Profile v2.0 when communicating with the Utility.

Security.Access.16 Only HAN Devices that are Registered with an ESI shall be able to communicate secured data directly with that ESI.

Security.Access.17 ESI shall be the clear information and security boundary between the Service Provider network (e.g. AMI network, internet, broadband, local area network, gateway to local devices, etc.) and Registered HAN Device(s) providing protection for each from exploits on the other.

Security.Access.18 HAN device shall prevent the unauthorized release of information.

[22] This Recommendation provides guidance when using the cryptographic features of current systems. It is intended to help system administrators and system installers adequately secure applications based on product availability and organizational needs, and to support organizational decisions about future procurements. The guide also provides information for end users regarding application options left under their control in the normal use of the application).

1

Table 9: Security Access Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	ESI shall provide access control (i.e., logical segmentation) to Service Provider applications, data, and services (e.g. control data, consumer-specific consumption data).	S	S	NA	NA	NA	NA	S	S	NA	NA	NA	NA
2	HAN Device shall control access to persistent HAN data (data at rest).	S	S	S	S	S	S	S	S	S	S	S	S
3	HAN Device shall provide protection of transmitted HAN data (data in transit).	S	S	S	NA	S	S	S	S	S	S	S	S
4	HAN Device shall provide protection of HAN data while being processed (data in processing).	S	S	O	NA	S	S	S	S	O	S	S	S
5	HAN Device shall control access to data in accordance with a managed security policy when logically linking one or more networks.	S	S	S	S	S	S	S	S	S	S	S	S
6	ESI shall provide mechanisms to enforce a policy based on least privilege (i.e., explicit authorization) for communications with the ESI.	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	ESI shall have the ability to enforce policy periods (time constraints) for security policy elements for communications with the ESI.	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 9: Security Access Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
8	HAN Device shall provide methods to query and report access control data settings.	S	S	S	S	S	S	S	S	S	S	S	S
9	HAN Device shall provide protect ion against applicable known attacks, including but not limited to replay, man-in-the-middle, delay, spoofing, sequence change, denial of service and deletion attacks.	S	S	S	S	S	S	S	S	S	S	S	S
10	HAN Device shall implement mechanisms to prevent unintended disclosure of source and originator data to unauthorized parties	S	S	S	S	S	S	S	S	S	S	S	S
11	HAN Device shall implement controls which limit access to audit information.	S	S	O	NA	S	O	S	S	O	S	S	S
12	HAN Device shall support cryptographically verifiable operations that provide confidentiality and integrity.	S	S	S	S	S	S	S	S	S	S	S	S
13	The application shall provide a means for authorized users to configure HAN Devices to communicate with one or more ESIs.	NA	NA	S	S	S	S	S	S	S	S	S	S
14	The HAN device shall follow NIST SP 800-57, Recommendation for Key Management.	S	S	S	S	S	S	S	S	S	S	S	S

Table 9: Security Access Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
15	Utility ESI and AMI Meter shall comply with the AMI Security Profile v2.0 when communicating with the Utility.	S	NA	NA	NA	NA	NA	S	S	NA	NA	NA	NA
16	Only HAN Devices that are Registered with an ESI shall be able to communicate secured data directly with the ESI.	NA	NA	S	S	S	S	S	S	S	S	S	S
17	The ESI shall be the clear information and security boundary between the Service Provider network (e.g. AMI network, internet, broadband, local area network, gateway to local devices, etc.) and Registered HAN Device(s), providing protection for each from exploits on the other.	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
18	HAN device shall prevent the unauthorized release of information.	S	S	S	S	S	S	S	S	S	S	S	S

1

3.6.2 Integrity

The integrity security service addresses prevention of unauthorized modification of data (both stored and communicated). Modification of both stored and communicated data may include changes, insertions, deletions or duplications. Additional potential modifications that may result when data is exposed to communications channels include sequence changes. The integrity service also addresses the problem of ensuring that communicating components can correctly identify those that they are communicating with.

Requirements:

Security.Integrity.1 Devices connected to the HAN shall not degrade the integrity of the HAN.

Security.Integrity.2 ESI shall provide a configurable filtering function (e.g. message structural integrity, message rate, message type, etc.) that filters messages transmitted bi-directionally between HAN devices and the Service Provider through the ESI.

Security.Integrity.3 ESI shall enable security policy deployment and enforcement for the purpose of protecting assets upstream of the ESI.

Security.Integrity.4 ESI shall enable security policy deployment and enforcement for the purpose of protecting HAN Devices Registered to the ESI.

Security.Integrity.5 HAN Device shall detect unauthorized modification of security-related data during storage.

Security.Integrity.6 HAN Device shall detect unauthorized modification of data during transit.

Security.Integrity.7 HAN Device shall attempt to correct an error, or conditions around an error, causing an unauthorized modification of data.

Security.Integrity.8 HAN Device shall accept data only from authorized trusted sources.

Security.Integrity.9 HAN Device shall not act on data which has been identified as modified in an unauthorized manner in transit.

Security.Integrity.10 HAN Device shall verify the authenticity of identity context for incoming data at all times.

Security.Integrity.11 HAN Device shall protect the HAN from malicious code (e.g. buffer overflow protection, limit executable code exposure).

Security.Integrity.12 HAN Device shall separate security critical functionality and data from non-security critical system data.

Security.Integrity.13 HAN Device shall validate the source of HAN security policy.

Security.Integrity.14 HAN Device shall detect unauthorized modification of HAN security policy.

Security.Integrity.15 HAN Device shall detect unauthorized modification of audit data.

Security.Integrity.16 HAN Device shall cryptographically validate the integrity and proof of origin of all software updates, including source, structure, and version.

Security.Integrity.17 HAN Device shall permit system updates to be initiated only remotely at the application layer or directly at the device.

Security.Integrity.18 HAN Device shall cryptographically verify integrity and proof of origin of system update images at rest prior to use.

Security.Integrity.19 HAN Device shall transmit and shall only receive system update images that are individually encrypted.

Security.Integrity.20 HAN Devices shall timely update system images following delivery of valid image.

Security.Integrity.21 HAN Device shall actively confirm that a system update was successful and revert to a prior system image if not successful.

Security.Integrity.22 HAN Devices shall permanently retain a known default system image that is separate from the current or updated firmware image. The device shall be capable of being remotely commanded to revert to the known default system image.

Security.Integrity.23 HAN Device shall use tamper-resistant hardware.

Security.Integrity.24 HAN Device shall accept security material updates in accordance with the security policy.

Security.Integrity.25 The ESI shall be configurable to detect and take appropriate action towards registered HAN devices that are impairing the performance of the ESI.

Security.Integrity.26 HAN device shall protect against or limit the launch of denial-of-service attacks against itself.

Security.Integrity.27 ESI shall protect against or limit the launch of denial-of-service attacks against HAN Devices.

Security.Integrity.28 ESI shall protect against or limit the launch of denial-of-service attacks to Service Provider systems (e.g. electric grid, AMI, back office systems, etc.).

Security.Integrity.29 HAN Device authentication credentials shall be established and validated in a manner that provides assurance the credentials were issued by the Service Provider and / or manufacturer

and shall be protected and updated by a mechanism consistent with the requirements used to protect the firmware.

1

Table 10: Security Integrity Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	Devices connected to the HAN shall not degrade the integrity of the HAN.	S	S	S	S	S	S	S	S	S	S	S	S
2	ESI shall provide a configurable filtering function (e.g. message structural integrity, message rate, message type, etc.) that filters messages transmitted bi-directionally between HAN devices and the Service Provider through the ESI.	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	ESI shall enable security policy deployment and enforcement for the purpose of protecting assets upstream of the ESI.	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	ESI shall enable security policy deployment and enforcement for the purpose of protecting HAN Devices Registered to the ESI	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	HAN Device shall detect unauthorized modification of security-related data during storage.	S	S	O	O	O	O	S	S	O	O	O	S
6	HAN Device shall detect unauthorized modification of data during transit.	S	S	S	S	S	S	S	S	S	S	S	S
7	HAN Device shall attempt to correct	S	S	S	S	S	S	S	S	S	S	S	S

Table 10: Security Integrity Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
	an error, or conditions around an error, causing an unauthorized modification of data.												
8	HAN Device shall accept data only from authorized trusted sources.	S	S	S	S	S	S	S	S	S	S	S	S
9	HAN Device shall not act on data which has been identified as modified in an unauthorized manner in transit.	S	S	S	S	S	S	S	S	S	S	S	S
10	HAN Device shall verify the authenticity of identity context for incoming data at all times	S	S	S	S	S	S	S	S	S	S	S	S
11	HAN Device shall protect the HAN from malicious code (e.g. buffer overflow protection, limit executable code exposure).	S	S	S	S	S	S	S	S	S	S	S	S
12	HAN Device shall separate security critical functionality and data from non-security critical system data.	S	S	NA	NA	NA	NA	S	S	NA	S	S	NA
13	HAN Device shall validate the source of HAN security policy.	S	S	NA	NA	S	NA	S	S	NA	S	S	NA
14	HAN Device shall detect unauthorized modification of HAN security policy.	S	S	NA	NA	S	NA	S	S	NA	S	S	NA
15	HAN Device shall detect unauthorized modification of audit data.	S	S	O	NA	S	O	S	S	O	S	S	O

Table 10: Security Integrity Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
16	HAN Device shall cryptographically validate the integrity and proof of origin of all software updates, including source, structure, and version.	S	S	S	S	S	S	S	S	S	S	S	S
17	HAN Device shall permit system updates to be initiated only remotely at the application layer or directly at the device.	S	S	S	S	S	S	S	S	S	S	S	S
18	HAN Device shall cryptographically verify integrity and proof of origin of system update images at rest prior to use.	S	S	S	S	S	S	S	S	S	S	S	S
19	HAN Device shall transmit and shall only receive system update images that are individually encrypted.	S	S	S	S	S	S	S	S	S	S	S	S
20	HAN Devices shall timely update system images following delivery of valid image.	S	S	S	S	S	S	S	S	S	S	S	S
21	HAN Device shall actively confirm that a system update was successful and revert to a prior system image if not successful.	S	S	S	S	S	S	S	S	S	S	S	S
22	HAN Devices shall permanently retain a known default system image that is separate from the current or updated firmware image. The device shall be capable of being remotely commanded to	S	O	O	O	S	O	S	S	O	O	O	O

Table 10: Security Integrity Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
	revert to the known default system image.												
23	HAN Device shall use tamper-resistant hardware.	S	O	O	O	O	O	S	S	O	S	S	O
24	HAN Device shall accept security material updates in accordance with the security policy.	S	S	S	S	S	S	S	S	S	S	S	S
25	The ESI shall be configurable to detect and take appropriate action towards registered HAN devices that are impairing the performance of the ESI.	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
26	HAN device shall protect against or limit the launch of denial-of-service attacks against itself.	S	S	S	O	S	S	S	S	O	S	S	S
27	ESI shall protect against or limit the launch of denial-of-service attacks against HAN Devices.	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
28	ESI shall protect against or limit the launch of denial-of-service attacks to Service Provider systems (e.g. electric grid, AMI, back office systems, etc.)	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 10: Security Integrity Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
29	HAN Device authentication credentials shall be established and validated in a manner that provides assurance the credentials were issued by the Service Provider and / or manufacturer and shall be protected and updated by a mechanism consistent with the requirements used to protect the firmware.	S	S	S	S	S	S	S	S	S	S	S	S

3.6.3 Accountability

Accountability can be considered a special type of non-repudiation. The accountability security service holds each network entity responsible for its actions on that network.

Depending upon the type of device or the Service Provider program, certain devices may require functions that detect and audit events related to security violation and tampering. Device security requirements should provide a reasonable measure of protection for the Consumer and the Service Provider. The device security requirements are not intended to be the sole measure of protection and the entire environment should never be dependent upon the security measures implemented in end devices—they are simply one part, and an essential part, of the security program.

Requirements:

Security.Account.1 HAN Device shall alert the ESI of all detected, security-related violations, including access control, authentication, and integrity.

Security.Account.2 HAN Device shall audit and store all security-related violations, including access control, authentication, and integrity.

Security.Account.3 HAN Device shall provide, at a minimum, the following information for all detected security events: date and time of the event, type of event, device/user identity.

Security.Account.4 HAN Device shall provide the ESI access to audit data upon request.

Security.Account.5 HAN Device shall provide the ability to perform searches, sorts and filters of audit data based on date and time, type and/or user identity.

Security.Account.6 HAN Device shall provide the capability to identify mandatory and configurable audit elements.

Security.Account.7 ESI shall provide non-repudiation that a message was sent from the ESI to a HAN Device.

Security.Account.8 ESI shall provide non-repudiation that a reply was received from a HAN Device back to the ESI.

Security.Account.9 ESI shall provide a mechanism for source identification of data received from Registered HAN Devices and Service Provider.

Security.Account.10 ESI shall provide the capability for the Service Provider to audit the ESI security policies.

Security.Account.11 HAN Device shall only respond to incoming communications validated for authenticity, integrity, and authorization.

Security.Account.12 HAN Device shall provide, at a minimum, the following information for changes to a security setting or configuration: date and time of the event, type of event, device/user identity.

Security.Account.13 HAN Device shall provide the capability to configure audit record storage capacity, configure auditing to reduce the likelihood of such capacity being exceeded, and alert the Service Provider in the event that the capacity is exceeded.

1

Table 11: Security Accountability Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	HAN Device shall alert the ESI of all detected, security-related violations, including access control, authentication, and integrity.	S	S	S	NA	S	S	S	S	NA	S	S	S
2	HAN Device shall audit and store all security-related violations, including access control, authentication and integrity.	S	S	NA	NA	O	NA	S	S	NA	NA	O	O
3	HAN Device shall provide, at a minimum, the following information for all detected security violations: date and time of the event, type of event, device/user identity.	S	S	S	NA	S	S	S	S	S	S	S	S
4	HAN Device shall provide the ESI access to audit data upon request	S	S	NA	NA	O	NA	S	S	NA	NA	O	O
5	HAN Device shall provide the ability to perform searches, sorts and filters of audit data based on date and time, type and/or user identity.	S	S	NA	NA	O	NA	NA	NA	NA	NA	O	NA
6	HAN Device shall provide the capability to identify mandatory and configurable audit elements.	S	S	NA	NA	O	NA	NA	NA	NA	NA	O	NA

Table 11: Security Accountability Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
7	ESI shall provide non-repudiation that a message was sent from the ESI to a HAN device.	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	ESI shall provide non-repudiation that a reply was received from a HAN device back to the ESI.	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9	ESI shall provide a mechanism for source identification of data received from Registered HAN Devices, and Service Provider.	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	ESI shall provide the capability for the Service Provider to audit the ESI security policies.	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	HAN Device shall only respond to incoming communication validated for authenticity, integrity, and authorization	S	S	S	S	S	S	S	S	S	S	S	S
12	HAN Device shall provide, at a minimum, the following information for changes to a security setting or configuration: date and time of the event, type of event, device/user identity.	S	S	O	NA	O	O	S	S	O	O	O	S

Table 11: Security Accountability Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
13	HAN Device shall provide the capability to configure audit record storage capacity, configure auditing to reduce the likelihood of such capacity being exceeded, and alert the Service Provider in the event that the capacity is exceeded.	S	S	NA	NA	O	NA	S	S	NA	NA	O	O

1

3.6.4 Registration

The Registration and authenticating requirements are used in conjunction with most other security services. The first step of most security services is to determine the identities of one or more of the parties participating in an action. A trusted identity must be used for access control decisions and to provide accountability evidence. Knowing the identity of an entity and the existence of a peer relationship is also fundamental to establishing communication with confidentiality and integrity. If the identity of the peer in a secure communications path is not properly established, it leaves open the possibility that an unauthorized principal (an adversary) could masquerade as an authorized principal, exposing the data to disclosure or manipulation.

Requirements:

Security.Reg.1 HAN Device shall support Mutual Authentication for two-way communications and originator authentication for one-way communications.

Security.Reg.2 HAN Device shall provide a mechanism which allows for multiple and configurable authentication materials (e.g. device ID, device type, key, serial key, device configuration, certificate, etc.).

Security.Reg.3 HAN Device shall be configured with authentication materials (e.g. certificate, etc.).

Security.Reg.4 HAN Device shall not store or send authentication materials over the network in an insecure fashion (e.g. do not transmit passwords or keys in the clear).

Security.Reg.5 HAN Device shall support a defined Registration process.

Security.Reg.6 HAN Device shall provide a means to update (i.e. change, reconstitute, rollover) authentication materials.

Security.Reg.7 HAN Device shall support a de-registration process and, if applicable, a de-registration process for other devices Registered to that HAN device.

Security.Reg.8 ESI shall support a configurable expiration period for the Registration process (e.g. Registration timeout, Registration persistence).

Security.Reg.9 HAN Device shall use security services (i.e. cryptographic services) which are either FIPS-approved or NIST-recommended.

Security.Reg.10 HAN Device shall support a Registration method that employs cryptographic operations (e.g. digital signatures).

Security.Reg.11 HAN Device shall provide notification of the Registration status (e.g. successful, pending, failed, etc.).

Security.Reg.12 ESI shall enable remote network and security configuration/control including the ability to remotely configure the rules (i.e., policies) which governs its logical network and interactions with its Registered devices.

Security.Reg.13 HAN Device shall be uniquely identified for the Registration process (e.g. Vehicle Identification Number, Electronic Serial Number, MAC address, networking details, Installation codes, Service Point Location, meter number, ESI security credentials, ESI ID, etc.).

Security.Reg.14 ESI shall accept HAN Device Registration configuration from an authorized source.

Security.Reg.15 When an ESI is triggered (e.g. Allow Join Command), HAN Device location-/contact-specific data shall be provided to other HAN Devices in the premises.

Security.Reg.16 ESI shall have the ability to accept or reject device requests based on Service Provider-specific information (e.g. network ID, gateway ID, or Service Provider ID).

Security.Reg.17 ESI shall maintain a current list of Registered HAN Devices and make that list available upon authorized request.

Security.Reg.18 An authorized user shall be able to Register a HAN Device either locally or remotely (e.g. through a Web Portal or other 3rd Party registration service [i.e. retail store, depot, or other]).

Security.Reg.19 ESI shall send an error message to the Service Provider when a request to Register a HAN Device has not been successfully completed within a configurable amount of time.

Security.Reg.20 ESI shall transmit the status of the HAN Device Registration (e.g. successful, pending, failed, etc.) to the party who is requesting the device Registration.

Security.Reg.21 An authorized user (e.g. Utility, Service Provider, Consumer, etc.) shall be able to remotely or locally de-Register a HAN Device.

Security.Reg.22 HAN Device shall support Registration to multiple ESIs.

1

Table 12: Registration Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	HAN Device shall support Mutual Authentication for two-way communications and originator authentication for one-way communications.	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
2	HAN Device shall provide a mechanism which allows for multiple and configurable authentication materials (e.g. device ID, device type, key, serial key, device configuration, certificate, etc.).	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
3	HAN Device shall be configured with authentication materials (e.g. certificate, etc.).	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
4	HAN Device shall not store or send authentication materials over the network in an insecure fashion (e.g. do not transmit passwords or keys in the clear).	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
5	HAN Device shall support a defined Registration process.	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
6	HAN Device shall provide a means to update (i.e., change, reconstitute, rollover) authentication materials.	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
7	HAN Device shall support a de-registration process and, if applicable, a de-registration process for other devices Registered to that HAN device.	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP

Table 12: Registration Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
8	ESI shall support a configurable expiration period for the Registration process (e.g. Registration timeout, Registration persistence).	RP	RP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9	HAN Device shall use security services (i.e. cryptographic services) which are either FIPS-approved or NIST-recommended.	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
10	HAN Device shall support a Registration method that employs cryptographic operations (e.g. digital signatures).	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
11	HAN Device shall provide notification of the Registration status (e.g. successful, pending, failed, etc.).	O	O	O	O	O	O	O	O	O	O	O	O
12	ESI shall enable remote network and security configuration/control including the ability to remotely configure the rules (i.e. policies) which governs its logical network and interactions with its Registered devices.	RP	RP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13	HAN Device shall be uniquely identified for the Registration process (e.g. Vehicle Identification Number, Electronic Serial Number, MAC address, networking details, Installation codes, Service Point Location, meter number, ESI security credentials, ESI ID, etc.).	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP

Table 12: Registration Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
14	ESI shall accept HAN Device Registration configuration from and authorized source.	RP	RP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	ESI shall have the ability to accept or reject a Registration request based on device type and ID.	RP	RP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	ESI shall have the ability to accept or reject device requests based on Service Provider-specific information (e.g. network ID, gateway ID, or Service Provider ID).	RP	RP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	ESI shall maintain a current list of Registered HAN Devices and make that list available upon request.	RP	RP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
18	An authorized user shall be able to Register a HAN Device either locally or remotely (e.g. through a Web Portal or other 3rd Party registration service [i.e. retail store, depot, or other]).	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
19	ESI shall send an error message to the Service Provider when a request to Register a HAN Device has not been successfully completed within a configurable amount of time.	RP	RP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20	ESI shall transmit the status of the HAN Device Registration (e.g. successful, pending, failed, etc.) to the party who is requesting the device Registration.	RP	RP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 12: Registration Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
21	An authorized user (e.g. Utility, Service Provider, Consumer, etc.) shall be able to remotely or locally de-Register a HAN Device.	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
22	HAN Device shall support Registration to multiple ESIs.	O	O	O	O	O	O	NA	NA	O	O	O	O

1

3.6.5 Enrollment

Enrollment is the process by which a Consumer enrolls a Registered HAN Device in a Service Provider's program (e.g. demand response, energy management, pre-pay, PEV programs, distributed generation programs, pricing, messaging, etc.) and gives certain rights to the Service Provider to communicate with their HAN Device. This process creates a program relationship between the HAN Device and the Service Provider's back office.

Requirements:

Security.Enroll.1 HAN Device shall authenticate the source of all Control Signals.

Security.Enroll.2 HAN Device shall accept Enrollment configuration (e.g. Service Provider ID, program ID, etc.) from authorized user.

Security.Enroll.3 ESI shall support authorized users' (e.g. Utility, Consumer, Service Provider, etc.) access to Enrolled HAN Devices.

Security.Enroll.4 HAN Device shall have the ability to be assigned to a group.

Security.Enroll.5 HAN Device shall allow for un-enrolling a HAN Device from a Service Provider program.

Security.Enroll.6 ESI shall provide an authentication mechanism which proxies for the Service Provider (e.g. negotiates on behalf of the Service Provider) during the Enrollment process.

1

Table 13: Enrollment Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	HAN Device shall authenticate the source of all Control Signals.	BF	BF	BF	NA	BF	BF	NA	NA	BF	BF	BF	NA
2	HAN Device shall accept Enrollment configuration (e.g. Service Provider ID, program ID, etc.) from authorized user.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
3	ESI shall support authorized users' (e.g. Utility, Consumer, Service Provider, etc.) access to Enrolled HAN Devices.	BF	BF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	HAN Device shall have the ability to be assigned to a group.	O	O	O	O	O	O	O	O	O	O	O	O
5	HAN Device shall allow for un-enrolling a HAN Device from a Service Provider program.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
6	ESI shall provide an authentication mechanism which proxies for the Service Provider (e.g. negotiates on behalf of the Service Provider) during the Enrollment process.	BF	BF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

2

3.7 Performance Requirements

The HAN SRS performance requirements are intended to maintain the quality of the HAN communications over the short and long term. Often performance of a system is characterized by reliability, availability and scalability.

Performance requirements are designed to ensure HAN applications and devices are:

- consistently reachable,
- designed and manufactured to be durable and resilient,
- easy to diagnose and manage,
- expandable to support future growth,
- remotely upgradeable (e.g. patches, updates, enhancements) without a field visit, and
- performing as advertised (i.e., quality).

Requirements:

Perf.1 HAN Device shall supply functionality that maintains communications availability to the ESI.

Perf.2 HAN Device shall supply functionality that maintains application availability, as applicable, to the ESI (e.g. software/hardware application watchdog).

Perf.3 After loss of power, HAN Device shall return to its post-configuration state (i.e. shall persist communication and Registration configurations).

Perf.4 HAN Device shall supply adequate computational performance (i.e. Device shall not hamper overall operational state of the HAN).

Perf.5 HAN Device shall supply accurate time keeping and counter functions.

Perf.6 HAN Device shall not act on expired signals or messages (e.g. message validity duration or sequence).

Perf.7 HAN Device shall provide configurable communications such that system is scalable (e.g. heartbeat and request frequency).

Perf.8 For battery-powered HAN Devices, HAN Device shall function for a minimum of 1 year without requiring replacement of the battery.

Perf.9 HAN Device shall supply a field-programmable software upgrade function (i.e. firmware upgrade).

Perf.10 HAN Device shall supply a remote software upgrade function (i.e. firmware upgrade, application upgrade).

Perf.11 HAN Device shall meet the quality, interoperability, and testing (i.e. certification) requirements of its respective technology platform body.

Perf.12 HAN Device shall accept a reference time from the ESI.

Perf.13 ESI and HAN Device shall accept and utilize a reference time from a Service Provider-approved source (i.e. a shared understanding of time).

Perf.14 HAN Device shall support remote configuration.

Perf.15 HAN Device shall use a structured, extensible information message schema.

Perf.16 HAN Devices shall support discrete (self contained) data.

Perf.17 HAN Devices shall support unordered data exchange.

Perf.18 HAN Devices shall support self-describing data across versions (e.g. device types, device attributes, device functions, etc.).

Perf.19 HAN Device shall support the local currency for energy applications.

Perf.20 HAN Device shall provide configurable sampling rate for application data (e.g. 5 seconds, 15 minutes, hourly, charging session, daily, etc.).

Perf.21 HAN Device shall support a valid date/time/duration for each piece of information or message.

Perf.22 HAN Device shall support variable length text messages (e.g. freeform messages conveying information, configuration, status, control).

Perf.23 The HAN shall provide communications (e.g. bandwidth, throughput, range, latency, reliability, extensibility, etc.) from the ESI to HAN Devices and between HAN Devices for multiple deployment scenarios including, but not limited to, large single or two story house, medium apartment, small apartment, multi-dwelling unit, and strip mall store.

Perf.24 HAN Device shall provide adequate feedback in a reasonable amount of time (e.g. 0.1 second, 1.0 second, 10 second requirements found at: Response Times: 3 Important Limits)

Perf.25 HAN Devices (including ESI) shall not modify priority of messages.

Perf.26 HAN Devices (including ESI) shall be able to support delivery of messages in near real-time within the HAN.

Perf.27 ESI shall accept mean and operational tolerances for time resolution and time synchronization of messages and data from the authorized provider's time source.

Perf.28 ESI shall report the lack of an acknowledgement for message delivery from a HAN Device.

Perf.29 HAN Devices (including ESI) shall provide explicit error messages for a range of device and communication failures (e.g. unrecognized message, out of range/low signal strength, low battery level, feature not supported, meter faults, HAN Device faults,

communication errors, etc) that facilitate effective troubleshooting by the authorized user (e.g. Service Provider, Installer, or automated systems).**Perf.30** HAN Device shall use a randomization algorithm to resume an in-progress battery charging session after a loss and subsequent restoration of external AC power.

1

Table 14: Performance Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	HAN Device shall supply functionality that maintains communications availability to the ESI.	NA	NA	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
2	HAN Device shall supply functionality that maintains application availability, as applicable, to the ESI (e.g. software/hardware application watchdog).	NA	NA	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
3	After loss of power, HAN Device shall return to its post-configuration state (i.e. shall persist communication and Registration configurations).	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
4	HAN Device shall supply adequate computational performance (i.e. Device shall not hamper overall operational state of the HAN).	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
5	HAN Device shall supply accurate time keeping and counter functions.	BF	BF	O	O	O	O	BF	BF	O	O	BF	O
6	HAN Device shall not act on expired signals and messages (e.g. message validity duration or sequence).	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
7	HAN Device shall provide configurable communications such that the system is scalable (e.g. heartbeat and request frequency).	O	O	O	O	O	O	O	O	O	O	BF	O

Table 14: Performance Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
8	For battery-powered HAN Devices, HAN Device shall function for a minimum of 1 year without requiring replacement of the battery.	NA	NA	O	O	O	O	NA	NA	O	O	NA	O
9	HAN Device shall supply a field-programmable software upgrade function (i.e. firmware upgrade).	BF	BF	O	O	O	O	BF	O	O	O	BF	O
10	HAN Device shall supply a remote software upgrade function (i.e. firmware upgrade).	BF	BF	O	O	O	O	BF	O	O	O	O	O
11	HAN Device shall meet the quality, interoperability, and testing (i.e. certification) requirements of its respective technology platform body.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
12	HAN Device shall accept a reference time from the ESI.	NA	NA	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
13	ESI and HAN Device shall accept and utilize a reference time from a Service Provider-approved source (i.e. a shared understanding of time).	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
14	HAN Device shall support remote configuration.	BF	BF	O	O	O	O	BF	O	O	O	O	O
15	HAN Device shall use a structured, extensible information message schema.	O	O	O	O	O	O	O	O	O	O	O	O
16	HAN Devices shall support discrete (self contained) data.	O	O	O	O	O	O	O	O	O	O	O	O
17	HAN Devices shall support unordered data exchange.	O	O	O	O	O	O	O	O	O	O	O	O

Table 14: Performance Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
18	HAN Devices shall support self-describing data across versions (e.g. device types, device attributes, device functions, etc.).	O	O	O	O	O	O	O	O	O	O	O	O
19	HAN Device shall support the local currency for energy applications.	BF	BF	BF	O	O	BF	BF	BF	O	BF	BF	BF
20	HAN Device shall provide configurable sampling rate for application data (e.g. 5 seconds, 15 minutes, hourly, charging session, daily, etc.).	BF	BF	BF	O	O	BF	BF	BF	O	BF	BF	BF
21	HAN Device shall support a valid date/time/duration for each piece of information or message.	BF	BF	BF	BF	BF	BF	BF	BF	O	BF	BF	BF
22	HAN Device shall support variable length text messages (e.g. freeform messages conveying information, configuration, status, control).	BF	BF	BF	BF	BF	BF	BF	BF	O	BF	BF	BF
23	The HAN shall provide communications (e.g. bandwidth, throughput, range, latency, reliability, etc.) from the ESI to HAN Devices and between HAN Devices for multiple deployment scenarios including, but not limited to, large single or two story house, medium apartment, small apartment, multi-dwelling unit, and strip mall store.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF

Table 14: Performance Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
24	HAN Device shall provide adequate feedback in a reasonable amount of time (e.g. 0.1 second, 1.0 second, 10 second requirements found at: Response Times: 3 Important Limits)	BF	BF	BF	O	O	BF	BF	BF	O	BF	BF	BF
25	HAN Devices (including ESI) shall not modify priority of messages.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
26	HAN Devices (including ESI) shall be able to support delivery of messages in near real-time within the HAN.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
27	ESI shall accept mean and operational tolerances for time resolution and time synchronization of messages and data from the authorized provider's time source.	O	O	O	O	O	O	O	O	O	O	O	O
28	ESI shall report the lack of an acknowledgement for message delivery from a HAN Device.	BF	BF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 14: Performance Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
29	HAN Devices (including ESI) shall provide explicit error messages for a range of device and communication failures (e.g. unrecognized message, out of range/low signal strength, low battery level, feature not supported, meter faults, HAN Device faults, communication errors, etc) that facilitate effective troubleshooting by the authorized user (e.g. Service Provider, Installer, or automated systems).	BF	BF	BF	O	O	BF	BF	BF	O	BF	BF	BF
30	HAN Device shall use a randomization algorithm to resume an in-progress battery charging session after a loss and subsequent restoration of external AC power.	NA	NA	NA	NA	NA	NA	NA	NA	NA	BF	BF	NA

3.8 Operations, Maintenance, and Logistics Requirements

The HAN SRS requirements for operations, maintenance, and logistics speak to supply chain standards for HAN Devices, including manufacturing, configuring, labeling, and packaging as well as standards for installation assistance, user manuals, online support, and device self-testing and troubleshooting.

3.8.1 Manufacturing and Distribution

These requirements speak to a vendor's pre-installation activities, including manufacture, depot, distribution, and point-of-sale. The goal of these requirements is to clearly establish responsibilities and enable the widest diversity of supply chain options for Service Providers and Consumers.

Requirements:

OML.ManuDist.1 Prior to installation (e.g. factory, depot), HAN Device shall support placement of Commissioning data (e.g. pre-placed device credentials).

OML.ManuDist.2 Prior to installation (e.g. factory, depot), HAN Device shall support placement of Registration data (e.g. pre-placed Registration credentials).

OML.ManuDist.3 HAN Device shall support pre-placed methods or materials that support the Commissioning and Registration process.

OML.ManuDist.4 HAN Device shall have and display appropriate Commissioning and Registration information on its body (e.g. serial number, installation code, MAC IDs for network interfaces, etc.).

OML.ManuDist.5 HAN Device shall display its HAN network technology compatibility on its outside packaging and body.

OML.ManuDist.6 HAN Device shall display, on its packaging, any secondary device requirements (e.g. required EMS, bridge device, gateway, etc.).

OML.ManuDist.7 HAN Device shall display, on its packaging, any power requirements (e.g. battery powered, plug in, etc.).

1

Table 15: Manufacturing and Distribution Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	Prior to installation (e.g. factory, depot), HAN Device shall support placement of Commissioning data (e.g. pre-placed device credentials).	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP
2	Prior to installation (e.g. factory, depot), a HAN Device shall support placement of Registration data (e.g. pre-placed Registration credentials).	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP	RP
3	HAN Device shall support pre-placed methods or materials that support the Commissioning and Registration process.	CP, RP	CP	RP	CP	RP	CP	RP	CP	RP	CP	CP	RP
4	HAN Device shall have and display appropriate Commissioning and Registration information on its body (e.g. serial number, installation code, MAC IDs for network interfaces, etc.).	NA	BF	BF	BF	BF	BF	NA	NA	BF	BF	BF	BF
5	HAN Device shall display its HAN network technology compatibility on its outside packaging and body.	BF	BF	BF	O	O	BF	BF	BF	O	BF	BF	BF
6	The HAN Device shall display, on its packaging, any secondary device requirements (e.g. required EMS, bridge device, gateway, etc.).	NA	O	O	O	O	O	NA	O	O	O	O	O
7	HAN Device shall display, on its packaging, any power requirements (e.g. battery powered, plug in, etc.).	NA	O	O	O	O	O	NA	O	O	O	O	O

2

3.8.2 Installation

These requirements speak to vendor responsibilities in support of physical placement of the HAN Device. The goal of these requirements is to ensure a smooth installation process regardless of the Installer with a minimum need for Consumer support from the Manufacturer and the Service Provider.

Requirements:

OML.Install.1 HAN Device Manufacturer, or supplier, shall include installation documentation that includes instructions for installation (e.g. placement, need for batteries, etc.), Commissioning and Registration, including any external dependencies.

OML.Install.2 HAN Device Manufacturer, or supplier, shall include a HAN Device user's manual in the device packaging.

OML.Install.3 HAN Device Manufacturer, or supplier, shall include Manufacturer contact information in the device packaging.

OML.Install.4 HAN Device Manufacturer, or supplier, shall supply technical support services (e.g. help desk, web site, etc.).

1

Table 16: Installation Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	HAN Device Manufacturer, or supplier, shall include installation documentation that includes instructions for installation (e.g. placement), Commissioning, and Registration, including any external dependencies.	NA	NA	BF	BF	BF	BF	NA	NA	BF	BF	BF	BF
2	HAN Device Manufacturer, or supplier, shall include a HAN Device user's manual in the device packaging.	NA	NA	O	O	O	O	NA	NA	O	O	BF	O
3	HAN Device Manufacturer, or supplier, shall include Manufacturer contact information in the device packaging.	NA	NA	O	O	O	O	NA	NA	O	O	BF	O
4	HAN Device Manufacturer, or supplier, shall supply technical support services (e.g. help desk, web site).	NA	NA	O	O	O	O	NA	NA	O	O	BF	O

3.8.3 Manage, Maintain

These requirements speak to vendor responsibilities for consumer support. They ensure HAN Devices enable diagnostic, management, and troubleshooting capabilities. The goal of these requirements is to grant Service Providers the ability to remotely resolve problems with HAN Devices to quickly determine whether a Consumer needs to contact the Manufacturer's customer support for further assistance.

Requirements:

OML.Maintain.1 HAN Device shall have a self-check (initialization) function that notifies the Installer the HAN Device is functioning properly.

OML.Maintain.2 ESI shall have a configurable ability (e.g. retention policy, etc.) to log all ESI-to-HAN System communications.

OML.Maintain.3 When the HAN Device is rebooted (e.g. power cycled, turned off, off due to power outage, etc.), HAN Device shall return to its state prior to losing connectivity (i.e., post-installation, Commissioning, Registration, and Enrollment, if applicable, state) and shall reestablish communication with the ESI.

OML.Maintain.4 HAN Device shall have a user-operable testing function that is equivalent to the self-testing function.

OML.Maintain.5 HAN Device shall supply a maintenance port for field diagnostics.

OML.Maintain.6 HAN Device shall simulate events for diagnostic purposes.

OML.Maintain.7 HAN Device shall supply Network Management functions for diagnostic purposes.

OML.Maintain.8 For battery-powered devices, HAN Device shall communicate low battery state to the Consumer and if the HAN Device is Enrolled in a Service Provider program, to the Service Provider.

OML.Maintain.9 HAN Device Manufacturer, or supplier, shall supply and support a flaw remediation process.

OML.Maintain.10 HAN Device shall support a communications feedback mechanism.

OML.Maintain.11 ESI shall automatically re-establish communication with Commissioned and Registered HAN Devices following any maintenance or upgrades (e.g. ESI replacement, software or firmware replacement, device communication card replacement, etc.).

OML.Maintain.12 HAN Device shall automatically re-establish communication with ESI following any maintenance or upgrades (e.g.

software or firmware replacement, device communication card replacement, etc.).

OML.Maintain.13 HAN Device shall support remote methods to manage and update authentication materials (e.g. digital certificates) in HAN Devices requiring no Consumer intervention.

OML.Maintain.14 HAN Device shall support diagnostic messages when errors (e.g. HAN Device faults, communications errors, etc.) are detected.

OML.Maintain.15 ESI shall provide methods and information needed for the Service Provider to troubleshoot where a communication fault occurred between an Enrolled device and the ESI.

OML.Maintain.16 HAN Device shall provide maintenance details (e.g. current date and time stamp of when the firmware was updated, firmware version number, etc.).

1

Table 17: Manage, Maintain Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
1	HAN Device shall have a self-check (i.e. initialization) function that notifies the Installer that the HAN Device is functioning properly.	NA	NA	O	O	O	O	NA	NA	O	O	BF	O
2	ESI shall have a configurable ability (e.g. retention policy, etc.) to log all ESI-to-HAN System communications.	BF	BF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	When the HAN Device is rebooted (e.g. power cycled, turned off, off due to power outage, etc.), HAN Device shall return to its state prior to losing connectivity (i.e. post-installation, Commissioning, Registration, and Enrollment, if applicable, state) and shall reestablish communication with the ESI.	NA	NA	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
4	HAN Device shall have a user-operable testing function that is equivalent to the self-testing function.	O	O	O	O	O	O	O	O	O	O	BF	O
5	HAN Device shall supply a maintenance port for field diagnostics.	O	O	O	O	O	O	O	O	O	O	BF	O
6	HAN Device shall simulate events for diagnostic purposes.	O	O	O	O	O	O	O	O	O	O	BF	O
7	HAN Device shall supply network management functions for diagnostic purposes.	O	O	O	O	O	O	O	O	O	O	BF	O

Table 17: Manage, Maintain Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
8	For battery-powered devices, HAN Device shall communicate low battery state to the Consumer and, if the HAN Device is Enrolled in a Service Provider program, to the Service Provider.	O	O	O	O	O	O	O	O	O	O	BF	O
9	HAN Device Manufacturer, or supplier, shall supply and support a flaw remediation process.	O	O	O	O	O	O	O	O	O	O	BF	O
10	HAN Device shall support a communications feedback mechanism.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
11	ESI shall automatically re-establish communication with Commissioned and Registered HAN Devices following any maintenance or upgrades (e.g. ESI replacement, software or firmware replacement, device communication card replacement, etc.)	BF	NA	NA	NA	NA	NA	BF	NA	NA	NA	NA	NA
12	HAN Device shall automatically re-establish communication with ESI following any maintenance or upgrades (e.g. software or firmware replacement, device communication card replacement, etc.).	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
13	HAN Device shall support remote methods to manage and update authentication materials (e.g. digital certificates) in HAN Devices requiring no Consumer intervention.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF

Table 17: Manage, Maintain Requirements Mapping

ID	HAN System Requirements	Utility ESI	ESI	PCT	IHD	EMS	Load Control	AMI Meter	HAN Meter (non-electric)	Smart Appliance	EVSE	PEV	EUMD
14	HAN Device shall support diagnostic messages when errors (e.g. HAN Device faults, communications errors, etc.) are detected.	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF
15	ESI shall provide methods and information needed for the Service Provider to troubleshoot where a communication fault occurred between an Enrolled device and the ESI.	BF	BF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	HAN Device shall provide maintenance details (e.g. current date and time of when the firmware was updated, firmware version number, etc.).	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF	BF

1

4. Appendices

4.1 Use Cases

4.1.1 Other Use Cases and Documents Reviewed

In addition to the use cases included in this SRS, the OpenHAN TF reviewed the following use cases to identify any gaps in the HAN requirements.

- ZigBee+HomePlug Joint Working Group Smart Energy Profile Marketing Requirements Document (MRD)
- J2836/1™ Use Cases for Communication between Plug-in Vehicles and the Utility Grid (Surface Vehicle Information Report).
- J2836/2™ Use Cases for Communication between Plug-in Vehicles and the Supply Equipment (EVSE) (Surface Vehicle Information Report).
- J2836/3™ Use Cases for Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow (Surface Vehicle Information Report).
- Draft Requirements Specifications for Common Electricity Product and Pricing Definition – for NIST PAP03
- Draft Requirements Specifications for Common Scheduling Mechanism for Energy Transactions – for NIST PAP04
- Draft Requirements Specifications for Retail Standard DR Signals – for NIST PAP09
- Energy Information Standards (EIS) Alliance Customer Domain Use Cases v1.0
- California Energy Commission Requirements Engineering for the Advance Metering Infrastructure and the Home Automation Network (AMI-HAN) interface – February 2008
- Smart Grid White Paper: The Home Appliance Industry's Principles & Requirements for Achieving a Widely Accepted Smart Grid (AHAM White Paper)
- Distributed Energy Resources Contribution to OpenHAN; EPRI/DOE PV/Storage Communication Project
- Summary of Use Cases: For Demand Response Appliances Interface (EPRI Adapters)

4.1.2 UCAIug OpenHAN Task Force Use Cases

The UCAIug OpenHAN Task Force developed these use cases as a way to bound the development of the system decomposition and requirements. They are written at a very high level and are by no means comprehensive. They are highly dependent on

other back office systems and processes that are assumed to exist and be in place. Each utility looking to implement a HAN or Service Provider wanting to offer HAN enabled programs will want to expand upon these use cases.

4.1.2.1 Methodology

These use cases focus on functional capabilities rather than device specific capabilities. Use case actors and scenarios may refer to a device, but the working group generally strove to describe the use case by its function.

4.1.2.2 Use Case Categories

Use cases are broken into four general use case categories:

- Load (kW) and Energy (kWh) Management
  - Voluntary Load Reduction
  - Mandatory Load Reduction
  - Energy Management System
- User Information
  - Complex Interactive
  - Simple One-way
- In-premises Metering
  - Energy Storage and Generation
  - Fixed HAN Device with Metering Capability
  - Mobile HAN Device with Metering Capability
- System Configuration and Management
  - HAN Device Installation & Commissioning
  - HAN Device Registration (e.g. application/devices)
  - HAN Device Remote Diagnostics and Troubleshooting
  - HAN Device Diagnostics and Maintenance
  - HAN Device Depot Configuration (optional)

4.1.2.3 Use Case Template

The template for use cases is as follows:

- Use Case Title
- Use Case Description
- Use Case Business Rules and Assumptions
- Use Case Scenarios (sequenced)

4.1.3 Actors

Actor Name	Actor Type
Consumer	Person
HAN Devices	Devices
AMI	System
Metering System	System
Energy Services Interface (ESI) / Utility ESI	Function
Customer Service System (CSS)	System
Automated Data Collection System	System
Pool Pump Controller	Device
Customer Representative	Person or System
In-Home Display (IHD)	Device
Energy Management System (EMS)	Application

4.1.4 Load and Energy Management

The use cases in this section are based upon the definitions and assumptions set forth in this HAN SRS.

4.1.4.2 Voluntary Use Case for Registered HAN Devices

Description

A major benefit of the HAN is that it supports Consumer awareness of instantaneous kWh usage, electricity pricing, consumption, projected costs, rate tiers, and voluntary load reduction program events. As electricity demand on the grid increases and energy shortages become more frequent, the need for Service Providers to offer programs to Consumers which cause the reduction of energy consumption will also increase. The Service Provider will help facilitate load reduction at a consumer's site by communicating Control Signals (e.g. pricing, voluntary load reduction program events) to various enabling devices Registered to the ESI, each of which contains the requisite functionality at the Consumer's site. Voluntary load reduction events may be scheduled with advanced notice (e.g. 24 hrs) or near real-time. For the Service Provider to receive the desired Consumer response, it must provide timely pricing, event, and usage information.

Related to this scenario is the measurement of the response to financial incentives, energy price adjustments, and other voluntary demand response programs. The Consumer responses will be used to determine how and/or if the devices have responded to a pricing event, if the Service Provider needs to launch other demand response events to achieve the needed demand reduction, and help the Service Provider determine how to structure future voluntary load reduction programs, to ensure the Service Provider receives the best Consumer response.

This scenario includes the actual mechanism to distribute Control Signals to IHDs or Load Control devices within the home/business. It includes the mechanism by which the IHD will display current pricing and voluntary load reduction event information within the consumer's home/business. The Service Provider will initiate automatic load reduction at the Consumer's premises by communicating event and pricing information to Consumer HAN Devices, which will take action based on the Consumer's predefined settings. The Consumer will be able to program their load control specifications and refuse Service Provider load reduction requests. The Consumer will also be able to manually curtail load based upon informational messages communicated to them from a Service Provider.

This scenario also includes the actual HAN functionality for Consumer HAN Devices and describes the scenario for separate HAN Devices classes and AMI-related behavior of the HAN Devices.

Troubleshooting for installation, Commissioning, Registration, and event failure should refer to the Section 4.1.11.4 HAN Device Diagnostics and Maintenance.

Scenario Business Rules and Assumptions

- If the HAN Device offers a display, it is capable of displaying actual price of power for a unit of time and/or providing an indication of relative price (e.g. low, medium, high, critical).
- The HAN Device is capable of differentiating between emergency/reliability and/or price-response event signals.
- If the HAN Device offers a display, it is able to display messages comprised of alphanumeric characters, as delivered remotely from the Service Provider.
- Certain HAN Devices can distinguish or support various event types and take appropriate action based on the event.
- The Consumer must Enroll their device in a Service Provider demand response program or tariff and the HAN Device must be Registered with the ESI for the HAN Device to confirm its successful actuation of the event.

Use Case Scenario

Service Provider initiates a voluntary demand response event (e.g. Critical Peak Pricing Event).

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The Service Provider determines the need for a demand response event.	HAN Device	The Installation use case is successfully completed. The Commissioning use case is successfully completed. The Registration use cases are successfully completed. The HAN Device has either been pre-programmed to respond appropriately to price, consumption, load or event messages and/or the Consumer has manually programmed the HAN Device.	The Consumer will have been notified of an event, the event will have been autonomously launched by the Service Provider's system, the HAN Devices will have responded, the event will have ended and the Consumer equipment returned to its original state.

1

2 Steps for this scenario

3 These steps apply for both event actuation and restoration to initial HAN Device state.

4

Step #	Actor	Description of the Step
1	Service Provider	Service Provider sends a Control Signal to the Consumer's IHD and/or Load Control equipment (HAN Devices), via ESI for Consumer viewing, that an event start time has arrived.
2	ESI/HAN Devices	The Consumer's HAN Device receives the message, updates the event status (e.g. to active) and the HAN Device will perform Consumer preprogrammed action (e.g. raise thermostat by 4 degrees, lower thermostat to original state) reacting to Control Signal.
3	Consumer	Consumer may choose not to participate in economic or pricing event. Consumer overrides the automatic HAN Device actuation sequence.

4	ESI/HAN Devices	If requested, the Consumer's HAN Device will send an acknowledgement to ESI that it received the event message and the ESI sends acknowledgement to the Service Provider (dependent on type of Consumer equipment). If an acknowledgement is sent to the ESI by the HAN Device, the acknowledgement may include the device ID, message received date/time (in UTC time) by the display/control equipment and action taken (e.g. receive event info, raised thermostat by 4 degrees, A/C off) and date/time action taken. The HAN Device may also log events for future Consumer analysis and audit or send events to a different HAN Device to log events. If the Consumer overrode the event, the acknowledgement will signify message received but overridden by Consumer.
5	Service Provider	Curtailment period ends and Service Provider sends the command to restore HAN Devices to previous state or sends message that event has ended.
6	HAN Devices	HAN Devices may restore load on a random restoration schedule so as to create minimal impact to the distribution system.
7	HAN Devices	If requested, HAN Devices respond back to the ESI an acknowledgement confirming the receipt of event end notification.

4.1.4.3 Mandatory Use Case

Description

The mandatory load and energy management use case refers to demand response resources dispatched for reliability purposes. These events are mandatory due to the potential of the demand for power exceeding supply as a result of unexpected power plants going offline or congestion in transmission and/or distribution lines. This type of program does not allow the Consumer to opt-out of an event, except for medical emergency situations. The Consumer may be (1) Enrolled in, or (2) as condition of service, be defaulted to a mandatory demand response program used for grid management.

Control of a Consumer’s HVAC can be accomplished via a PCT, which is Enrolled in a Service Provider program. Other HAN Devices in a mandatory load and energy management program may include an EMS, a Pool Pump Controller, A/C switch, or even a passive device (one that does not actually shed load) such as an IHD that warns of potential power shortages in the near future or a load shed event in progress. The PCT may act as both a load shedding and passive/informational device. The Service Provider will send Control Signals to the ESI, which will forward the Control Signal to the HAN Device(s) capable of receiving it. Upon receipt and successful

execution of the load shed, the HAN Device(s) may return an acknowledgement back to the ESI, including logging and device status.

Mandatory/emergency load and energy management events may not allow Consumers the option to override the load shed request. The Service Provider relies on firm load shed to avert rotating outages. Giving Consumers the option to override a mandatory load shed request increases the possibility a complete power outage. For public safety purposes, the Service Provider must be able to immediately remove a Consumer off the program due to a medical emergency and restore operation to the HVAC as soon as possible.

Advanced warning of the event can vary as follows:

- Long term (e.g. 24 hours) and short term (e.g. few hours notice) predicted energy shortages
- Emergency shortage (e.g. few minutes notice)

The following is a list of use case scenarios:

1. Predicted mandatory load curtailment for grid management – Warnings are issued for possible electrical system overload or potential lack of generation resources.
2. Consumer requests an immediate opt-out due to a medical emergency.

Use Case Business Rules and Assumptions

- Medical Opt-out devices are pre-registered or may register upon Consumer contacting the Service Provider to exclude their HAN Device from mandatory events.

Use Case Scenarios

Scenario 1

Service Provider initiates a mandatory demand response event due to a possible electrical system overload or potential generation/demand imbalance. Warnings issued to Consumers are optional.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The Service Provider determines the need for a demand response event.	HAN Device	The Installation use cases are successfully completed. The Commissioning use cases are successfully	The Consumer may have been notified of an event, the Control Signal will be sent by the Service Provider's System, the HAN Devices

		completed. The Registration Use Cases are successfully completed. The HAN Device has been programmed by the Service Provider or Consumer to shed load on command.	will respond and the event will have ended and the Consumer equipment returned to its original state.

1

2 Steps for this scenario

3 These steps apply for both event activation and restoration to initial HAN Device state.

Step #	Actor	Description of the Step
1a	Service Provider	Service Provider anticipates the need to dispatch a mandatory curtailment program.
1b	Service Provider	Service Provider anticipates the need to dispatch a mandatory curtailment program and sends a warning message to the Consumer HAN Device.
2	HAN Devices	HAN Devices receive the warning message that a mandatory event occurred and displays the appropriate message (e.g. lights the appropriate LED) (** optional step **)
3	Service Provider	Service Provider sends a mandatory load shed message (Control Signal).
4	HAN Devices	HAN Devices receive the Control Signal.
5	HAN Devices	Han Devices respond appropriately to the Control Signal
6	HAN Devices	If requested, HAN Devices acknowledge to the ESI, confirming the receipt of the Control Signal.
7	Service Provider	Curtailment period ends and Service Provider sends the command to restore HAN Devices to previous state.
8	HAN Devices	HAN Devices restore load on a random restoration schedule so as to create minimal impact to the distribution system.
9	HAN Devices	If requested, HAN Devices acknowledge to the ESI, confirming the receipt of event end notification.

4

Scenario 2

Service Provider initiates a mandatory demand response event due to a possible electrical system overload or potential lack of generation resources. Consumer calls the Service Provider to opt-out of the program due to a medical emergency.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The Service Provider determines the need for a demand response event.	HAN Device	The Installation use cases are successfully completed. The Commissioning use cases are successfully completed. The Registration use cases are successfully completed. The HAN Device has been programmed by the Service Provider or Consumer to shed load on command.	The Consumer opts-out of the program and the HAN Device being controlled is restored to the initial state.

Steps for this scenario

These steps apply for both event actuation and opting the Consumer out of the program.

Step #	Actor	Description of the Step
1	HAN Devices	HAN Devices receive the Control Signal from the Service Provider to start the curtailment.
2	HAN Devices	HAN Devices responds appropriately to the Control Signal.
3	HAN Devices	If requested, HAN Devices acknowledge to ESI receipt of the Control Signal.
4	Consumer	Consumer contacts the Service Provider to opt-out of the event and restore load.
5	Service Provider	Service Provider sends the message to restore load to the appropriate HAN Devices.
6	HAN Devices	HAN Devices immediately restore load.

Step #	Actor	Description of the Step
7	HAN Devices	If requested, HAN Devices acknowledge to the ESI, receipt of the message to restore load.
8	Consumer	Consumer contacts Service Provider and requests that the HAN Devices be removed from the mandatory load and energy management program. (optional)

4.1.5 Energy Management System

Description

An EMS can provide value to the Consumer by accessing and analyzing current, historical, and projected energy use. An EMS may automatically control selected loads in the Consumer premises according to Consumer preference, energy use, electricity price, home occupancy, weather forecasts, or other factors. When combined with a time-based rate plan, the EMS can be expected to reduce load during high price periods, meeting both the Consumer's wishes and the needs of the Service Provider.

4.1.5.1 Registered EMS Reduces Consumer Premises Energy Use

Description

EMS establishes HAN communication with the Utility ESI through the Commissioning and subsequent Registration processes. EMS gains access to three types of data: usage data from the electric meter, private Consumer data (e.g. energy program and rate data), that the utility may transmit to the EMS through the Utility ESI and public information which the utility may choose to transmit to all Consumer HAN devices via the Utility ESI (note: this is dependent upon the policy in the Consumer's jurisdiction). It is not necessary for the HAN devices to be Enrolled in a Utility program to access this information.

Consumer interacts with the EMS using a web browser, mobile phone, or other display device to define preferences for energy use and automation. Preferences may be based on a single factor, such as a time or price for energy, or a combination of factors such as occupancy, type of activity, DER production, and current price.

Once Registered and configured, the EMS continuously provides information and control services utilizing its rules and internal algorithms. EMS may control one or many devices in the premises, including energy producing devices such as solar panels. EMS makes decisions affecting total energy usage of the premises, optimizing the load of various devices under its control.

Use Case Business Rules and Assumptions

- The EMS is a HAN Device which is able to communicate with the Utility ESI and is able to request and receive usage information from the utility meter.

- The EMS is able to interact with the Consumer.
- The EMS has rules or algorithms to process the applicable input activities, interpret them relative to the Consumer's desires, and create the appropriate actions.
- The EMS, when managing loads, has access to those loads. The managed loads may or may not be on the same HAN or communication network as the Utility ESI.
- The EMS may acquire additional information for its decisions from the Internet, through other communication methods, or other devices.
- The EMS may be selected and owned by the Consumer, or provided by the utility or another Service Provider.

This use case supports but does not require that the utility transmit one-way public or private information to the ESI such as emergency or price events. The utility may also transmit such information via the Internet or alternative means.

Use Case Scenario

Load is reduced at appropriate times automatically or manually.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
Cost or usage exceeds the preference of the Consumer under the current circumstances	EMS	The EMS is successfully installed. The Commissioning and Registration use cases are successfully completed for the EMS. The preferences of the Consumer are known by the EMS.	EMS automatically and/or Consumer manually manages load within Consumer preference until cost is reduced or excessive usage is concluded. Load is then resumed as appropriate.

Steps for this scenario

Step #	Actor	Description of the Step
1	EMS	EMS monitors usage continuously from the AMI Meter.
2	EMS	EMS keeps current price updated. This may be achieved by previous input of rate plan information or receipt of price messages from various sources.
3 A ***or***	Consumer	Consumer increases consumption, DER production decreases, or occupant activity changes (e.g. occupants return from work).

Step #	Actor	Description of the Step
3 B	Utility	Energy price increases due to TOU rate or message sent by Utility.
4	EMS	EMS applies rules or algorithms to the change in consumption or price.
5	EMS or Consumer	If a preference threshold has been exceeded, EMS automatically reduces the total load of the premises by managing one or more devices, under its control, according to appropriate preferences of the Consumer or notifies the Consumer to take specific actions.
6	Consumer	Consumer may override the commands of the EMS.
7	EMS	EMS ensures the load remains reduced until the condition in Step 3 is reversed or Consumer override occurs.

4.1.5.2 EMS Registered to Utility ESI and Enrolled in Service Provider Program via Secondary ESI

Description

EMS is registered to Utility ESI (as in use case 4.1.6.1). Consumer then enrolls in a Demand Response program from a secondary (e.g. non-utility) Service Provider, henceforth referred to as SP2. The SP2 demand response program, for example, may be structured to control specific loads or to require reductions in total premises load (e.g. actual KWh used). The program may have specific rules about the ability of the Consumer to override certain types of events, or how many times an event may be overridden in a given period of time. The Consumer may also enroll in additional Service Provider programs like a DER program.

This use case places requirements on the EMS to accept additional decision-making inputs from SP2 and communicate additional status and acknowledgement.

Use Case Business Rules and Assumptions

- All requirements and assumptions of EMS use case 4.1.6.1 are met.
- EMS is Registered to Utility ESI
- EMS receives energy price and use information from AMI Meter
- SP2 Demand Response program provides Consumer benefits for changing energy use patterns during certain periods or identified conditions.
- SP2 provides a logical ESI and communicates with that ESI through the Internet.
- SP2 allows EMS to communicate with SP2's logical ESI (i.e. EMS is Enrolled in SP2 program)

- SP2 communicates all of the rules of the Enrolled program in a manner which the EMS can understand.
- SP2's logical ESI has access to the Internet and that access is continuous or frequent enough to elicit timely response to Control Signals from SP2.
- EMS is able to incorporate all rules of the SP2 Program in its decisions and interactions with Consumer and devices under its control.

Use Case Scenario

Load is reduced in response to SP 2's Demand Response program automatically or manually.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
SP2 sends Control Signal to EMS requesting demand response.	EMS	The Commissioning, Registration, and Enrollment use cases are successfully completed for the EMS to be Enrolled in the SP2. The preferences of the Consumer and rules of the program are known by the EMS.	EMS automatically and/or Consumer manually curtails load within requirements of the SP2 and Consumer preferences during the period requested by the SP2. Load is then returned to an appropriate level following the end of the demand response event.

Steps for this scenario

Step #	Actor	Description of the Step
1	EMS	EMS monitors usage continuously from the meter via Utility ESI.
2	EMS	EMS keeps current price updated. This may be achieved by previous input of rate plan information or receipt of price messages from various sources.

Step #	Actor	Description of the Step
3	SP2	SP2 sends Control Signal to the EMS requesting demand response. It may define a start and end time in one signal or send separate start and end signals. The start time may be immediate or in the future. Control Signal may define control of HAN Device(s), an increased price, or an emergency signal.
4	EMS	EMS returns acknowledgement to the SP2 ESI, upon request, which will, at a minimum, confirm receipt of the Control Signal
5	EMS	At the appropriate time, EMS applies rules or algorithms to the Control Signal relative to Consumer preferences and monitored conditions. The start time may be modified by a random amount, if defined in the Control Signal.
6	EMS or Consumer	EMS automatically reduces the total load of the premises by managing one or more devices according to appropriate preferences of the Consumer or notifies the Consumer to take specific actions.
7	Consumer	Consumer may override the commands of the EMS.
8	EMS	If requested in the Control Signal, EMS will return a functional acknowledgement to the SP2 ESI. It may include information such as the action(s) taken, any Consumer override, and an estimate of the load dropped. If the Consumer overrides the action later, the EMS will communicate that to the ESI.
9	EMS	EMS ensures that the condition of the Control Signal and related Consumer preferences, including a Consumer override, are met during the defined period. This may require multiple additional actions by the EMS as the situation changes in the premises, particularly if the Control Signal was a price increase or request for specified demand response for the entire premises.

4.1.6 User Information

Consumer receives Service Provider initiated messages and electric usage updates via an In Home Display (IHD).

Description

An IHD is Commissioned and Registered with the Utility ESI and is Enrolled in a Service Provider program. The AMI Meter provides real-time usage information to the IHD and the Service Provider sends messages to the IHD.

Use Case Scenarios

A simple IHD provides basic display of Service Provider-generated price and Consumer-specific usage information.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
Consumer obtains IHD.	Consumer	The Installation use cases are successfully completed. The Commissioning use cases are successfully completed. The Registration use cases are successfully completed. The IHD has been Enrolled in a Service Provider program. The IHD has either been pre-programmed to display price, consumption, load or event messages and/or the Consumer has manually configured the IHD.	Consumer becomes more aware of their energy usage and the cost of that energy usage

<u>Steps for this scenario</u>

Step #	Actor	Description of the Step
1	IHD	The IHD indicates the status of the communication link with the ESI.
2	Service Provider	Service Provider sends messages to the IHD.
3	IHD	Displays Service Provider generated messages. (e.g. emergency event).
4	IHD	The IHD requests Consumer specific real-time data (e.g. demand, electric energy usage) from the AMI meter.
5	AMI meter	AMI meter provides usage data as requested. (e.g. demand (watts) every 6 seconds).
6	IHD	Displays usage information.
7	Consumer	Views information on IHD.

4.1.7 Energy Storage and Generation

Consumer uses a storage or generation unit to provide energy to their home or the grid.

Description

The Energy Supplying Unit (ESU) connects with the premises HAN, the ESI, and the electric system (home, vendor, or Utility's). The ESU identifies itself and the account it is associated with, and provides energy to the home or grid. This use case also describes the scenarios documented in *The Sub Metering Use Case* and *The Load and Energy Management Use Cases*, in that the ESU behaves according to these use cases.

Use Case Business Rules and Assumptions

- Energy Supplying Unit (ESU) has energy available.
- All Utility safety measures and rules are in place to provide power to the grid.

Use Case Scenario

The following scenario addresses storage and generation for the purpose of providing energy to the home or grid.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
Incentives or Utility requirements are in place for providing energy to the home or grid.	ESU	The Installation use cases are successfully completed. The Commissioning use cases are successfully completed. The Registration use cases are successfully completed. Units are transfer ready and properly connected.	Energy is successfully transferred.

Steps for this scenario

Step #	Actor	Description of the Step
1	EMS, ESI, other entity, ESU (Consumer acts on EMS or ESU)	Signals ESU to transfer energy.
2	ESU	Performs a self-check for sufficient capacity and generation readiness.
3	ESU	Transfers energy.
4	EMS, ESI, other entity, ESU (Consumer acts on EMS or ESU)	Signals to end transfer event. (e.g. due to drop in price, inadequate energy availability, Consumer preference, or Service Provider preference)
5	ESU	Ceases transfer of energy.

4.1.8 Fixed HAN Devices with Metering Capability

Description

The FHDMC connects with the premises HAN and identifies itself and the account it is properly associated with to the Service Provider, where premises owner's charges are reconciled. This use case also describes the scenario documented in *The Load and Energy Management Use Cases*, in that the FHDMC may behave according to that use

case. The following scenario is defined: bi-directional metering (i.e., DER) and third-party (i.e., gas meter).

Use Case Scenario

The following scenario addresses FHDMC, where bi-directional electric and third-party metering takes place.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
FHDMC is connected and enabled	FHDMC	The Installation use cases are successfully completed. The Commissioning use cases are successfully completed. The Registration use cases are successfully completed.	Device owner meters the device and gets billed for the appropriate amount on their electricity bill or other third-party bill.

Steps for this scenario

Step #	Actor	Description of the Step
1	FHDMC	Device indicates positive status of the communication link with the appropriate ESI.
2	FHDMC	Device provides the Consumer (end user) with the appropriate information. (e.g. current rate of consumption, etc)
3	FHDMC	Device accumulates usage (delivered or received) and returns the information to the ESI.
4	FHDMC	(optional) The device provides the ESI with additional state information if applicable (e.g. state of charge of a storage device).

4.1.9 Mobile HAN Device with Metering Capability

Description

The MHDMC connects with the premises Home Area Network (HAN), identifies itself and the account it is properly associated to the Service Provider. MHDMC's and premises owner's charges are reconciled, as applicable. This use case also describes the scenario documented in *The Load and Energy Management Use Cases*, in that the MHDMC may behave according to that use case. The mobile (e.g. any Consumer PEV) scenario is defined in this document.

Use Case Scenario

The following scenario addresses MHDMC, where bi-directional electric metering takes place.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
MHDMC is connected and enabled temporarily	MHDMC	The Installation use cases are successfully completed. The Commissioning use cases are successfully completed. The Registration use cases are successfully completed. The MHDMC is enrolled in a Service Provider program	MHDMC owner and premises owner bills are properly reconciled.

Steps for this scenario

Step #	Actor	Description of the Step
1	MHDMC	Device indicates positive status of the communication link with the appropriate ESI.
2	MHDMC	Device indicates to the user whether the MHDMC is recognized by the Service Provider (i.e., for billing purposes)

Step #	Actor	Description of the Step
3	MHDMC	(optional) Device provides the Consumer (end user) with the appropriate information. (e.g. percentage of charge, current rate of consumption, etc)
4	MHDMC	Device accumulates usage (delivered or received) and returns the information to the ESI.
5	MHDMC	(optional) The device provides the ESI with additional state information if applicable (e.g. state of charge of a storage device).

4.1.10 System Configuration and Management

4.1.10.1 HAN Installation and Commissioning

Description

The installation and Commissioning use cases cover the activities associated with physical installation and Commissioning. Commissioning establishes the communication path to the ESI. Once this process is complete then a HAN Device can be Registered with the ESI. The Registration and Commissioning processes are actually discrete operations.

This use case covers all HAN Devices including, but not limited to, PEV, PCT, Pool Pump Controller, EMS, etc. Commissioning ignores mobility related functions (e.g. PEV moving from premises to premises). That is, Mobility is an aspect of Enrollment.

The Installer may perform other diagnostics that the meter and HAN Devices cannot perform by itself. These steps are specific to the underlying technology and not covered in the high level use of the system.

It is important to note this use case covers various scenarios, including various HAN Devices (e.g. PCT, IHD, etc.), Service Provider delivers additional HAN Devices and Commissions to the existing HAN at time of meter installation, and Consumer Commissions the HAN Devices to the ESI after installation of an AMI System.

Use Case Business Rules and Assumptions

- For control devices, device is installed in-line at the appropriate control point (e.g. in series with the information or energy flow).
- All appropriate safety precautions are taken (e.g. qualified electrician is required for certain installation routines).
- Devices and applications are procured or provided through multiple distribution channels (e.g. retail, Utility-provided, etc.).
- Devices meet all applicable electrical, safety, and communications laws.
- Pre-commissioning routines have been successfully executed (e.g. pre-placed network key has been loaded).

Use Case Scenario

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
Consumer takes possession of HAN Device.	Consumer or Installer	ESI with two-way communications capability is present.	The Consumer device has been added to the local HAN network and has established communications with the ESI (i.e., the HAN has been established).

Step	Actor	Description of the Step	Additional Notes
1	Installer	Installer locates appropriate installation point.	Appropriate installation point considerations includes: signal strength at location, appropriate control point, etc.)
2	Installer	Device is installed.	Installation includes removing previous equipment and connecting the device to external power (if necessary)
3	HAN Device	HAN Device performs self-check and reports results to installer.	In certain installation instances, a field tool can assist in the device initialization and configuration.

Step	Actor	Description of the Step	Additional Notes
4	Installer	Installer inputs any required pre-commissioning materials (e.g. physical location, LAT/LONG, etc),	
5	Installer	Installer enters commissioning data (e.g. network key) or performs any necessary commissioning actions (e.g. proximity)	
6	HAN Device	HAN Device notifies the ESI or other network coordinator of its presence on the network.	This process is part of the technology-specific beaconing and discovery process. If a third-party device performs the actual commissioning, then the ESI needs to be notified through a separate process.
7	ESI	ESI acknowledges notification and authenticates network credentials	Authentication failures should be logged and a notification sent to authorized user. This is necessary due to possible security implications
8	ESI	Sends HAN Device any necessary configuration data (e.g. preferred communication paths, updates, etc.)	
9	ESI	Device is added to the network.	
10	HAN Device	HAN Device notifies the Installer (successful Commissioning)	
11	Consumer	Consumer contacts Service Provider and Service Provider provides Consumer the Registration instructions *Optional*	

4.1.10.2 HAN Device Registration

Description

The Registration use case covers device–to-ESI Registration. As a prerequisite to the use case, the device has already been Commissioned to the local network. Whereas, the installation and commissioning use case resulted in admission to the local HAN, the Registration use case covers the steps necessary to Register a HAN Device on the ESI. This implies that Registration is a higher level function.

The Registration process establishes a directional trust (i.e. Mutual Authentication) between the ESI and the HAN Device. The Registration use case does not cover details associated with Enrollment. These back office steps, while necessary, are outside the scope of this activity.

Use Case Business Rules and Assumptions

- Local HAN commissioning establishes the base communication capability, Registration rides on top of this commissioning and Enrollment rides on top of Registration.

Use Case Scenario

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
Consumer wants HAN Devices to participate in two-way communications with the ESI and other HAN Devices	HAN Device	The Installation and Commissioning use cases have been successfully completed.	The Consumer device will be registered with the ESI. All communications with the device will be protected, authenticated and acknowledged.

Steps for this scenario

Step	Actor	Description of the Step	Additional Notes
1	Consumer	Consumer makes decision to join their HAN Device to an ESI to enable the HAN Device to receive energy information from the AMI meter.	

2	Customer Representative	Customer Representative receives notification from Consumer that Consumer is ready to have one (or more) of their HAN Devices Registered with an ESI.	This process can be automated through a web based interface. (i.e., the web application is the Customer Representative)
5	Customer Representative	Customer Representative gets appropriate Consumer information (address, verification information, etc) and locates Consumer information from CSS	
6	Customer Representative	Customer Representative activates HAN Device Registration process by providing the unique HAN Device Registration information (eg. Registration key, serial number, etc.)	
7	HAN Device Registration process	HAN Device Registration initiates the HAN discovery process which identifies the Consumer's HAN Device.	If this process fails then the device has not been commissioned.
8	HAN Device Registration process	HAN Device Registration process attempts to mutually authenticate the HAN Device with the ESI and create an authenticated link with HAN Device using the Registration information.	This step can be staged. .
9	HAN Device Registration process	HAN Device Registration process sends appropriate Registration, configuration, and initiation messages to all applicable HAN and ESI devices.	
10	HAN Device(s)	HAN Device(s) acknowledges activation and readiness state(s) to HAN Device Registration process.	
11	HAN Device Registration process	HAN Device Registration process communicates all necessary information to CSS and other applicable systems for storage and any required internal registrations	

12	Customer Representative	Customer Representative confirms with the Consumer that HAN Devices have now been Registered.	
13	HAN Device	HAN Device provides notification to the Installer of its successful Registration	The HAN Device is now eligible to Enroll in a Service Provider program and to receive authorized information (e.g. meter usage data, etc.)

4.1.10.3 HAN Device Remote Diagnostics and Troubleshooting

Description

This use case discusses the scenario associated with remote Service Provider diagnostics. This use case does not cover all resolution scenarios. Resolution scenarios are specific to the underlying technology and based on warranties, ownership and accountability. These discussions are outside the scope of the base use case.

Use Case Business Rules and Assumptions:

- The scope of Service Provider responsibility for diagnostics and maintenance is limited.
- Accountability for troubleshooting is driven by several factors not addressed in these use cases.

Use Case Scenario

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
A HAN Device fails to receive Service Provider communications.	HAN Device	The Installation Commissioning and Registration Use Cases have been successfully completed.	The Consumer device is returned to an operational state.

Steps for this scenario

Step	Actor	Description of the Step	Additional Notes
1	Consumer	Contacts Customer Representative.	

2	Customer Representative	Identifies Consumer (verifies) and records Consumer issue.	
3	Customer Representative	Retrieves Consumer account (e.g. billing data, device registrations, program registrations, etc.)	
4	Customer Representative	Validates account status	
5a	Customer Representative	Corrects account or registration information (e.g. updates billing, updates program participation) and ends call.	
5b	Customer Representative	Starts remote diagnostics application.	
6	Remote Diagnostics application	Retrieves device commissioning data from ESI.	
7	Remote Diagnostic Application	Attempts to connect to HAN Device	
8a	Remote Diagnostic Application	Connection successful – commissioning confirmed,	
8b	Remote Diagnostic Application	Connection unsuccessful – repeat installation commissioning use case	
9	Customer Representative	Notifies Consumer that the Service Provider can or can not communicate with the HAN Device	
10a	Customer Representative	Schedules onsite maintenance	See HAN Device Diagnostics and Maintenance use case
10b	Customer Representative	Starts Registration Diagnostics Application	
11	Remote Diagnostic Application	Check application layer communication (e.g. send registered control signal)	
12	Customer Representative	Notifies the Consumer that the device is functioning or is not functioning correctly	

13a	Customer Representative	Registration communication unsuccessful – execute registration use case	See HAN Device Diagnostics and Maintenance use case
13b	Customer Representative	Schedules onsite maintenance	See HAN Device Diagnostics and Maintenance use case

4.1.10.4HAN Device Diagnostics and Maintenance

Description

This use case discusses the scenario associated with Service Provider maintenance and onsite diagnostics. This use cases does not cover all resolution scenarios. Resolution scenarios are specific to the underlying technology and based on warranties, ownership, and accountability. These discussions are outside the scope of the base use case.

Use Case Business Rules and Assumptions

- The scope of Service Provider responsibility for diagnostics and maintenance is limited.
- Accountability for troubleshooting is driven be several factors not addressed in these use cases.

Use Case Scenario

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
A HAN Device fails to communicate with the Service Provider	HAN Device	The Installation, Commissioning and Registration use cases have been successfully completed or attempted	The Consumer device is returned to an operational state.

Steps for this scenario

Step	Actor	Description of the Step	Additional Notes
1	HAN Device	HAN Device(s) cannot communicate with the Service Provider.	
2	HAN Device	HAN Devices notifies installer of communication failure.	
3	Consumer or Installer	Installer or Consumer uses field tool or HAN Device diagnostic capabilities to test network communication.	
4a	Consumer or Installer	Installer validates whether device is faulty.	
4b	Consumer or Installer	Installer validates adequate HAN network connectivity exists.	
5a	Consumer or Installer	Installer replaces HAN Devices, if appropriate.	
5b	Consumer or Installer	Reports marginal coverage if appropriate.	
6	Consumer or Installer	Performs problem and device specific resolution (e.g. installs a bridging device to mitigate poor signal strength, installs a higher power or more capable device, etc.)	

4.1.10.5 HAN Device Depot Configuration (optional)

Description

The device depot configuration use case discusses the steps associates with the preparation of the HAN Device (e.g. required certifications, pre-placed materials, or support modes). The depot (e.g. factory) steps show any necessary Service Provider to Manufacturer interactions.

Use Case Business Rules and Assumptions

- HAN Devices can be configured prior to installation.
- Compliance implies compatibility.

Use Case Scenario

Triggering Event	Primary Actor	Pre-Condition	Post-Condition

A HAN Device has been produced.	Manufacturer	Device supports required configurations and materials.	The HAN Device is ready for installation and Commissioning.

Steps for this scenario

Step	Actor	Description of the Step	Additional Notes
1	Manufacturer	Checks registration and authentication requirements	
2	Manufacturer	Determines any special destination-specific configurations (Optional)	
3	Manufacturer	Request Commissioning and Registration materials (e.g. keys, certificates, methods/functions)	
4	Manufacturer	Adds Registration specific materials/methods.	
5	Manufacture	Adds appropriate compliance/certification labeling.	
6	Manufacturer	Notifies or provides destination Service Provider with materials (e.g. keys) (Optional)	

4.2 HAN Security Considerations

This section considers the potential impact of HAN security compromise in the context of four categories of compromise scope. These categories provide rough orders of magnitude with which the security engineer may associate tangible undesirable outcomes and therefore justify certain costs associated with the implementation of controls. For each scope of compromise the tables below display possible impact to the different stakeholders surrounding a Home Area Network (HAN). The impact definitions can be found in the Federal Information Processing Standards (FIPS) Publication number 199[23] and are listed below:

The *potential impact* is **LOW** if—

- The loss of confidentiality, integrity, or availability could be expected to have a **limited** adverse effect on organizational operations, organizational assets, or individuals.

  AMPLIFICATION: A limited adverse effect means that, for example, the loss of confidentiality, integrity, or availability might: (i) cause a degradation in mission capability to an extent and duration that the organization is able to perform its primary functions, but the effectiveness of the functions is noticeably reduced; (ii) result in minor damage to organizational assets; (iii) result in minor financial loss; or (iv) result in minor harm to individuals.

The *potential impact* is **MODERATE** if—

- The loss of confidentiality, integrity, or availability could be expected to have a **serious** adverse effect on organizational operations, organizational assets, or individuals.

  AMPLIFICATION: A serious adverse effect means that, for example, the loss of confidentiality, integrity, or availability might: (i) cause a significant degradation in mission capability to an extent and duration that the organization is able to perform its primary functions, but the effectiveness of the functions is significantly reduced; (ii) result in significant damage to organizational assets; (iii) result in significant financial loss; or (iv) result in significant harm to individuals that does not involve loss of life or serious life threatening injuries.

The *potential impact* is **HIGH** if—

- The loss of confidentiality, integrity, or availability could be expected to have a **severe or catastrophic** adverse effect on organizational operations, organizational assets, or individuals.

  AMPLIFICATION: A severe or catastrophic adverse effect means that, for example, the loss of confidentiality, integrity, or availability might: (i) cause a severe degradation in or loss of mission capability to an extent and duration that the organization is not able to perform one or more of its primary functions; (ii) result in major damage to organizational assets; (iii) result in major financial loss; or (iv) result in severe or catastrophic harm to individuals involving loss of life or serious life threatening injuries.

[23] FIPS Publication 199, Standards for Security Categorization of Federal Information Systems, February 2004, pages 2-3

1 **Table 18: Scope of Compromise**

Scope of Compromise	Concerns	
Singular device within a single HAN	Magnitude of associated load or energy supply	Can the associated load or energy supply be manipulated?
	Credential / key information	Can the credential or key information be obtained and re-used by unauthorized entities?
	False / misleading messages for humans as well as other devices	Can humans and/or other devices be misled (i.e. tricked) into taking undesirable actions?
	Metrology / revenue information	Can metrology or revenue information be falsified?
	Personally Identifiable information (PII) theft	Can PII be exposed to unauthorized entities?
	Loss / destruction of device functionality (includes human safety)	Can a device's physical capabilities be turned against itself, other devices, or humans?
	Impact Ratings	
	Stakeholder	**Impact**
	Utility / Service Provider	Low
	Consumer	Moderate
	Premise owner	Low
	Vendor	Low
	Regulator / policy-maker	Low
Scope of Compromise	**Concerns**	
Multiple devices within a single HAN, up to and including all devices within a single HAN	Amplification of concerns for a single device	Can the associated load or energy supply be manipulated?
	Impact Ratings	
	Stakeholder	**Impact**
	Utility / Service Provider	Low
	Consumer	High
	Premise owner	Low
	Vendor	Low
	Regulator / policy-maker	Low

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1

Scope of Compromise	Concerns	
Multiple devices within multiple HANs (single neighborhood scale)	Service availability to neighbors (i.e. Transformer fuse)	Can enough load be shed or energy supplied to blow the transformer fuse for the associated neighborhood?
	Disruption of HAN functionality /Loss of consumer confidence/ Loss of reputation	Can enough devices be caused to misbehave such that the collective behavior causes a nuisance or that the public (or a portion thereof) loses trust in the technology.
	Damage to a distribution system asset	Can enough load be shed, energy supplied, or fluctuation be introduced (i.e. cycling) to damage a distribution asset or otherwise shorten its life expectancy?
	Synchronistic events (e.g. resource contention)	Can devices be manipulated by timing of normal otherwise normal operations in such a way as to overload system resources?
	Impact Ratings	
	Stakeholder	**Impact**
	Utility / Service Provider	Moderate
	Consumer	High
	Premise owner	Moderate
	Vendor	Low
	Regulator / policy-maker	Low
Scope of Compromise	**Concerns**	
Large number of HANs (multiple neighborhoods)	Denial of service to wide areas	Can capabilities/benefits of the technology be blocked for a substantial geographic area?
	Damage to a distribution system asset	Can enough load be shed, energy supplied, or fluctuation be introduced (i.e. cycling) to damage a distribution asset or otherwise shorten its life expectancy?
	Loss of revenue	Can the technology be manipulated in such a way as to prevent an organization from being able to realize fiscal benefit of their investment or meet contractual obligations?
	Misuse / abuse of system	Can the technology be manipulated in such a way as to create widespread undesirable effects?
	Breach of sensitive information (e.g. PII, corporate sensitive information, etc.)	Can a large-scale breach expose sensitive information to unauthorized entities?
	Impact Ratings	

	Stakeholder	Impact
	Utility / Service Provider	High
	Consumer	High
	Premise owner	High
	Vendor	High
	Regulator / policy-maker	High

Scope of Compromise	Concerns	
Extension into a network beyond the HAN	Compromise of command and control	Can the ESI be used as a conduit to facilitate breach of command and control (i.e. operation of the AMI network or capabilities such as remote disconnect)?
	Using the end point gateway to affect denial of service to a significant area	Can the ESI be leveraged to launch a wide-scale attack on a substantial portion of the AMI network?
	Malicious use of devices upstream, route malicious payload upstream, affect or alter command and control upstream, or affect/alter back-end office systems upstream	Can a connection to a 3rd party service provider be leveraged to compromise said service provider? Can the technology and communication channels be used as a conduit for attacks against other utility/service provider systems?
	Damage to a distribution system asset	Can enough load be shed, energy supplied, or fluctuation be introduced (i.e. cycling) to damage a distribution asset or otherwise shorten its life expectancy?
	Loss of revenue	Can the technology be manipulated in such a way as to prevent an organization from being able to realize fiscal benefit of their investment or meet contractual obligations?
	Misuse / abuse of system	Can the technology be manipulated in such a way as to create widespread undesirable effects?
	Breach of sensitive information	Can a large-scale breach expose sensitive information to unauthorized entities?
	Impact Ratings	
	Stakeholder	**Impact**
	Utility / Service Provider	High
	Consumer	High
	Premise owner	High
	Vendor	High
	Regulator / policy-maker	High