Data Acquisition and Control (DAC) Use Case

1 Descriptions of Function

All prior work (intellectual property of the company or individual) or proprietary (non-publicly available) work should be so noted.

1.1 Function Name

Data Acquisition and Control (DAC) Function

1.2 Function ID

IECSA identification number of the function

G-3.6,G-3.7,G-3.8,G-3.8.1,G-3.8.2,G-4,T-4.1,T-4.2,T-4.3,T-4.6,T-4.15,T-4.18,T-6,T-6.17,T-6.18,T-6.19,T-6.21,T-9,D-4,D-5,D-6,L-2,L-2.2,L-2.2.1,L-2.4

1.3 Brief Description

Describe briefly the scope, objectives, and rationale of the Function.

Scope: The Data Acquisition and Control (DAC) function, used in transmission and distribution operations, comprises multiple types of mechanisms for data retrieval from field equipment and the issuing of control commands to power system equipment in the field, including among field devices, between field devices and systems located in substations, and between field devices and various systems (including, but not limited to, SCADA systems) located in DER and utility control centers and engineering/planning centers.

Objectives: The DAC function provides real-time data, statistical data, and other calculated and informational data from the power system to systems and applications that use the data. The DAC function also supports the issuing of control commands to power system equipment and the setting of parameters in IEDs and other field systems.

Rationale: Power system real-time data is source of most information required for power system operations. Control over the power system equipment can be achieved by issuing control commands and setting parameters.

1.4 Narrative

A complete narrative of the Function from a Domain Expert's point of view, describing what occurs when, why, how, and under what conditions. This will be a separate document, but will act as the basis for identifying the Steps in Section 2.

The Data Acquisition and Control (DAC) function, used in transmission and distribution operations, comprises multiple types of mechanisms for data retrieval and issuing of control commands to power system equipment. These mechanisms are often used in conjunction with each other to provide the full range of DAC interactions. The DAC function, in turn, is used by other functions, such as Supervisory Control and Data Acquisition (SCADA) systems, Energy Management Systems (EMS), Protection Engineering systems, and Advanced Distribution Automation (ADA), as the means for their interactions with the power system equipment. The different mechanisms include the following:

1.4.1 Direct Power Equipment Control

Direct power equipment control is performed by an Intelligent Electronic Device (IED), a Remote Terminal Unit (RTU), or other microprocessor-based controller, sometimes based on internally generated control commands and sometimes based on externally requested control commands. These controllers monitor sensors for data about the power system and their associated power equipment (the actual equipment connected to the power system). The communications links are often very short (a few meters) but can also entail multi-mile links. The communications media typically are copper wires or optical fibers, but can include power line carrier, radio-based media, and possibly other media. They either use internal applications or are instructed by other entities to issue control signals to associated power system equipment. For example:

- A Load Tap Changer IED raises and lowers the transformer tap position according to pre-set algorithms, based on voltage levels sensed by Potential Transformers (PTs).
- A circuit breaker IED issues an electro-mechanical or solid-state-based trip signal to a circuit breaker.
- A DER IED controller senses status and measurements of a DER generator and its prime mover, and then issues start and stop signals.

1.4.2 Local IED Interactions

Local interactions among Intelligent Electronic Devices (IEDs) are undertaken to respond to a relatively local situation. The communications media are typically LANs, point-to-point cables, and point-to-multi-point radio channels. Protection actions require very high speed communication channels, with response timeframes of 1 to 4 milliseconds. For example:

- A protection IED issues a trip command over a high speed LAN to a circuit breaker IED within a substation, based on its detection of different power system measurements, such as low frequency, current overload, etc.
- Multiple automated switch IEDs, using point-to-multi-point spread spectrum radio communications media, respond to a fault condition on a feeder segment by opening and closing switches to isolate the fault and restore power to unaffected feeder segments.

1.4.3 Computerized Field Systems Monitoring and Control of Field Equipment via IEDs

Computerized field systems perform monitoring and control of field equipment via IEDs, such as a data concentrator or substation master or Automated Control and Data Acquisition (ACADA) (SCADA in a control center is considered in Section 1.4.5). These are generalized systems, as opposed to IEDs or controllers, and usually monitor and/or control more than one power system device. Data concentrators just pass data through them, acting primarily as communication nodes, although they may include a local database. Substation masters may include applications to perform some local interactions, or may help coordinate IED actions. ACADA systems may perform closed loop control (e.g. does not interact with the human operator before issuing a control command).

The communications media can be LANs, copper wire, optical cables, microwave, radio, leased telephone lines, cellphones, and many other types. Data exchanges range from a few 10's of milliseconds up to 1 second. Examples include:

- Data concentrator in a substation monitors data from IEDs that are located on feeders connected to the substation. It passes some of this data to a SCADA system and passes control commands from the SCADA to the IEDs. It may collect sequence of events data and some statistical information in a database.
- Substation master coordinates the protection settings of substation IEDs based on requests from the SCADA system for different response patterns. For instance, different protection trigger levels are set for recloser responses if a storm is pending, or if reconfiguration of a feeder impacts the expected fault current level, or if DER generation levels could cause fuses to blow unnecessarily.
- Substation master provides information to automated switch IEDs on a feeder as to the actual configuration of a neighboring feeder. This information will permit the automated switch IEDs to take more appropriate action if a fault occurs.
- Automatic Control and Data Acquisition (ACADA) performs Advanced Distribution Automation, by responding to field conditions reported by IEDs and issuing control commands for volt/var optimization, fault location, isolation, and restoration, multi-feeder reconfiguration, and other ADA functions..

1.4.4 DER Management Systems Monitoring and Control of DER Devices

DER management systems perform monitoring and control of a DER device, either at a customer site or within a substation (see Figure 1-1). The DER management system could be a DER owner's SCADA system, a customer's Building Automation System (BAS), or an energy aggregator's SCADA system. Communications media can include virtually any type, so long as response times of a few seconds can be accommodated. Examples include:

- Loss of power is detected at a customer site. The backup diesel generator starts up, the automatic transfer switch connecting the customer to the utility EPS opens, and the generator is connected to the customer's local EPS (or just the critical equipment).
- The owner of the DER device decides to reduce his load on the utility EPS by increasing generation. The DER operator implements this decision by setting new parameters in the DER management system. (These are manual actions by persons.) As an automated result, another generator is started by the DER management system, synchronized with the local EPS, and interconnected.
- An energy aggregator sets groups of DER devices to cycle on and off over the next day, taking into account pollution limits, the real-time price of energy, and contractual arrangements with the owners of the DER devices.
- While a DER device is interconnected with the utility EPS, a fault occurs on the feeder. The DER management system ensures that the DER device either trips off or the interconnection circuit breaker opens.
- The DER management system collects sequence-of-events, performance data, and statistical information from DER devices in a substation.

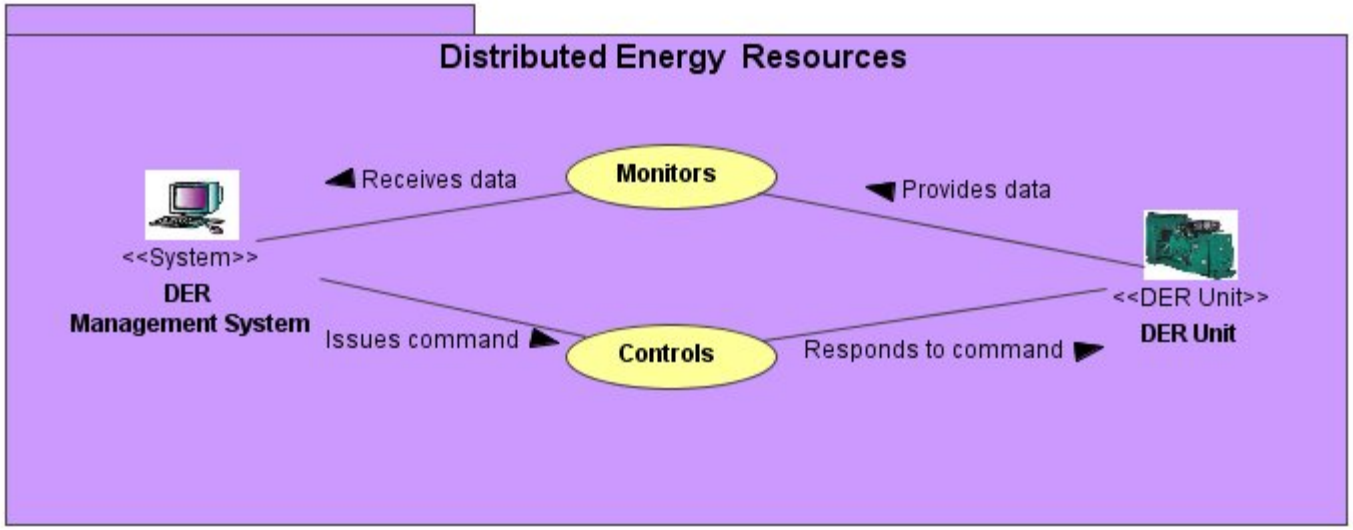


Figure 1-1: DER Management Systems Monitoring and Control of DER Devices

1.4.5 SCADA Systems Monitoring and Control of Field Equipment and IEDs

SCADA systems perform remote monitoring and control of field equipment and IEDs (see **Error! Reference source not found.**). The term "SCADA" is used here to imply any centralized system which retrieves data from remote sites and may issue control commands when authorized. These SCADA systems are typically located in a utility control center, but may include an engineering "SCADA" system which retrieves protection data or disturbance data, or a maintenance "SCADA" system which monitors the health of both power system and communications equipment.

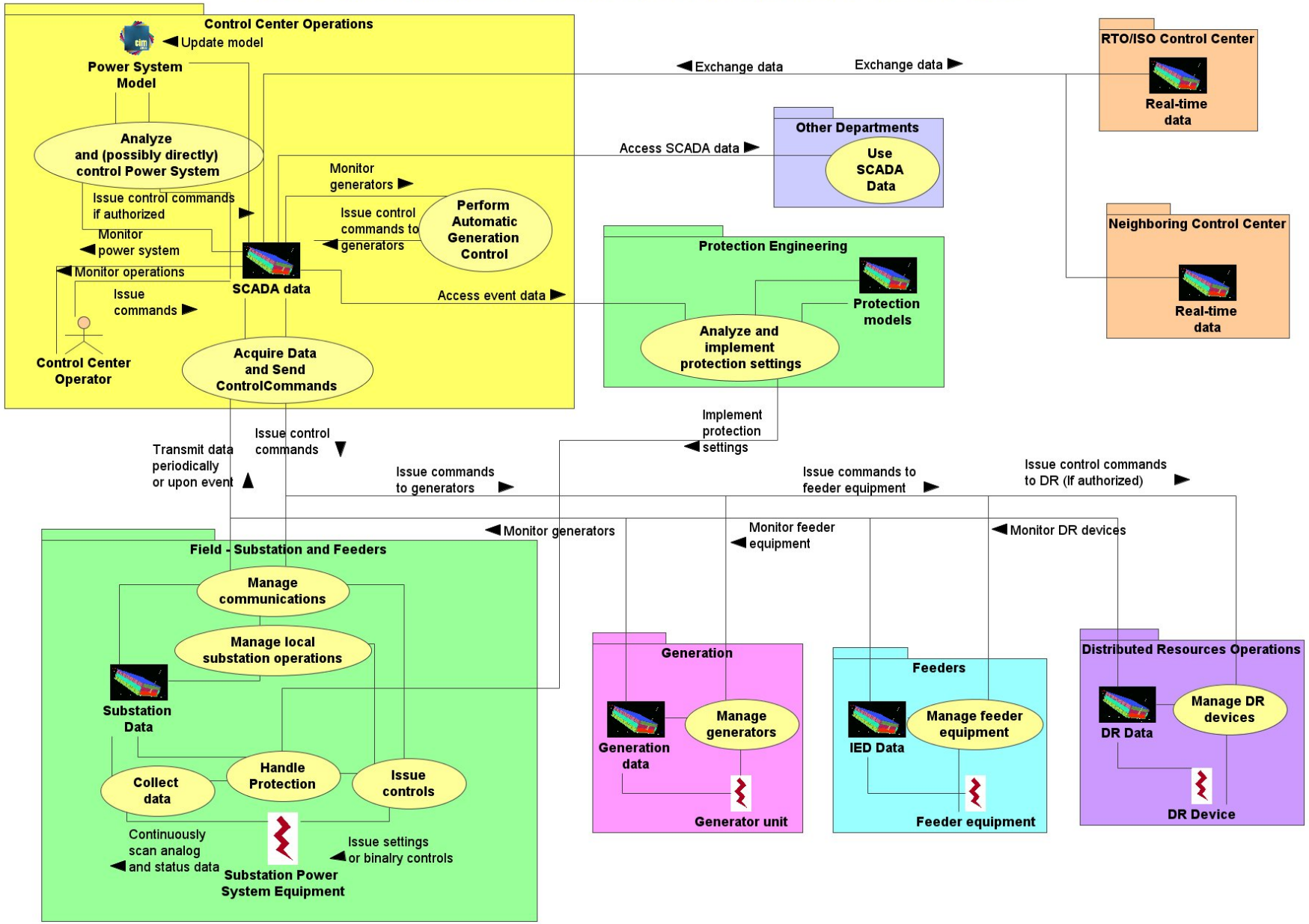
SCADA system monitoring can use communication channels directly to IEDs, via Remote Terminal Units (RTUs), through a data concentrator, through a substation master, or through a DER management system. The communications media can include virtually any type, so long as response times of 1 second can be accommodated. Although typically seen as used only for real-time distribution operations, the data acquired by the SCADA system can be used by many different systems, applications, and personnel in the control center. This Use Case is limited to the monitoring and control function by SCADA systems; other Use Cases (e.g. ADA Use Case) describe their interactions with the SCADA systems.

SCADA system monitoring and control examples include:

- Power system operations SCADA system receives real-time data from power system equipment via:
  - RTUs

  - IEDs inside substations
  - IEDs along feeders
  - Substation masters
  - DER (or other generation) management systems
  - Other control centers
  - Manual entry
- Power system operations SCADA system issues control commands to power system equipment in real-time via:
  - RTUs
  - IEDs inside substations
  - IEDs along feeders
  - Substation masters
  - DER (or other generation) management systems
  - Other control centers (if authorized)
- Power system operations SCADA system receives metering information
- Data management "SCADA" system receives power equipment configuration data from devices. It may have its own communication channels to the remote sites, or it may acquire this data through the distribution operations SCADA system
- Engineering "SCADA" system receives sequence of events data, oscillographic data (special handling required), historical data, and statistical data. It may have its own communication channels to the remote sites, or it may acquire this data through the distribution operations SCADA system
- Maintenance "SCADA" system receives data related to the health of power system equipment and communications equipment. It may have its own communication channels to the remote sites, or it may acquire this data through the distribution operations SCADA system.
- Planning "SCADA" system receives data that can be used for statistical analysis of power system measurements: maximums, minimums, averages, trends, profiles, power quality metrics, etc, needed for short and long term planning.

Figure 1-2: Data Acquisition and Control (DAC) in SCADA Operations on the Power System



1.5 Actor (Stakeholder) Roles

Describe all the people (their job), systems, databases, organizations, and devices involved in or affected by the Function (e.g. operators, system administrators, technicians, end users, service personnel, executives, SCADA system, real-time database, RTO, RTU, IED, power system). Typically, these actors are logically grouped by organization or functional boundaries or just for collaboration purpose of this use case. We need to identify these groupings and their relevant roles and understand the constituency. The same actor could play different roles in different Functions, but only one role in one Function. If the same actor (e.g. the same person) does play multiple roles in one Function, list these different actor-roles as separate rows.

1.5.1 Actors – Power System Field Equipment

Grouping (Community)		***Group Description***
Power System Field Equipment		
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
Power system equipment	Device	Power system equipment directly operates on the power system. It can be located anywhere on the power system. Common power system equipment includes CircuitBreaker, Load tap changers, capacitor banks, switches, VoltageRegulatorController, potential transformers (PTs), current transformers (CTs), meters, distributed energy resources (DER) devices, etc.
SensorDevice	Device	SensorDevice directly measure or monitor the power system, typically consisting of PTs and CTs.

Grouping (Community)		*Group Description*
Power System Field Equipment		
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
RemoteTerminalUnit	Device	An RTU collects data from power system equipment by converting sensor analog data into digital data. This digital data, in the form of status and analog "points" is then transmitted to a system over a communications channel. An RTU issues control actions by converting digital commands received from a system into electro-mechanical or solid-state actions that act on power system equipment. Some RTUS can also monitor and issue control commands to IEDs. They are generalist DAC devices, and do not normally include any applications associated with specific power system equipment. (If they do, they should be termed an IED or controller.)
IED or Controller	Device	An IED or a controller (deemed not quite as intelligent as an IED) controls the power system equipment. It also usually monitors power system data that is relevant to its possible control actions. It can be located in substations, along feeders, at customer sites, or anywhere where power system equipment is located
Substation master	System	A substation master collects data from IEDs, controllers, and power system equipment in substations. It could also collect data from distribution feeder equipment, although this is rarely done, since most substation masters are in large transmission substations as part of substation automation systems. It can also pass through control commands received from other systems.
DataConcentrator	System	A data concentrator is similar to substation master in configuration (i.e. located in a substation to collect data), but it is less likely to play an active role in responding to events. Collects data from IEDs, controllers, and power system equipment in substations. It can also pass through control commands received from other systems.
FieldPersonnel	Person	Work on power system equipment in the field, as instructed by work orders and as authorized by the distribution operator or other utility personnel
MaintenancePersonnel	Person	Maintains all field equipment, devices, and systems

Grouping (Community)		*Group Description*
Power System Field Equipment		
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
capacitor bank switches		
DERManagementSystem		
DEROperator		
DEROwner		
DERDevice		
Equipment		
LoadTapChangeController		
Protection		
RecloserDevice		
CircuitBreaker		
VoltageRegulatorController		

1.5.2 Actors – Control Center

Grouping (Community)		*Group Description*
Control Center		
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
Regional System Operator	Person	Regional System Operator monitor the power system using the User Interface of the SCADA system, as well as getting additional information from field crews and other control center systems. They also issue control commands to be executed either electronically through the SCADA system or manually by field crews.
SCADASystem	System	The SCADASystem retrieves data from the power system equipment, devices, and systems, and is used by operators and authorized applications to issue commands to power system equipment, devices, and systems.
Real time database	Database	The real-time database stores real-time data, primarily for the SCADA applications and user interface used by the distribution operators.
FieldEquipmentDatabase	Database	FieldEquipmentDatabase store data from field equipment that is needed by non-SCADA applications and systems, such as EMS applications, ADA applications, maintenance systems, planning systems, engineering analysis systems, etc. They can include some of the real-time database information, but also contain additional field data not needed by the SCADA operations. These databases are typically not in one system, but are often attached to applications and systems that use the data. Examples include disturbance analysis files, oscillographic data, protection data, maintenance data, and sequence of events data.
Power system applications	Software application	Power system applications, such as WAMACS, EMS, and ADA applications, use data from the real-time database and some application databases, as well as other control center database, to model the power system, analyze conditions, recommend response actions, and, if authorized, issue commands to field equipment.

Replicate this table for each logic group.

1.6 Information exchanged

Describe any information exchanged in this template.

Information Object Name	*Information Object Description*
Raw sensor data	Raw (unprocessed) data from sensors and field equipment
Signal data	Control commands: can be contact closures, relaying signals, or digital commands
Sensor data	Electrical parameters, status of equipment
Fault sensor data	Fault indication: overcurrent, low frequency, etc
Trip command	Trip signal
Control response sensor data	Electrical measurements (indicating no power)
Digital electric data	Status and measurements
Settings	Parameter values such as voltage level trigger points or wait time for reclose attempt – these may be measurement values or state values (on/off)
IED SOE	Timestamped sequence of event data
SBO control request	Control command, security authorization information, select before operate sequence
Call by person	Voice or written words
DER data entry	Amount of additional generation
DER start-up command	Start command and additional parameters
DER reporting	DER status, generator data, electrical data, prime mover data, fuel data, environmental data
DER historical and statistical records	DER status, generator data, electrical data, prime mover data, fuel data, environmental
DER stop command	Stop command and other pertinent parameters
User display	DER status, generator data, electrical data, prime mover data, fuel data, environmental data
Association	Protocol parameters Information on RTU or IED configuration and available data List of available data Information on groups of data (data sets) to be sent under different circumstances
Status change	Digital status

Information Object Name	*Information Object Description*
Measurement change	Digital measurement values
Control command	Control commands to power system equipment Control command to IED to initiate an IED process
Parameter setting	Raise/lower settings Threshold and limit settings State conditions
Request	Requested data
SCADA SOE	Log of timestamped events showing data changes and other values

1.7 Activities/Services

Describe or list the activities and services involved in this Function (in the context of this Function). An activity or service can be provided by a computer system, a set of applications, or manual procedures. These activities/services should be described at an appropriate level, with the understanding that sub-activities and services should be described if they are important for operational issues, automation needs, and implementation reasons. Other sub-activities/services could be left for later analysis.

Activity/Service Name	*Activities/Services Provided*
Association	Establishes an association between two or more entities. It also handles aborts and cancellation of associations
Monitoring analog sensor data	Monitor data from sensors and convert the sensor input into digital integers or floating point numbers
Monitor binary sensor data	Monitor data from sensors and convert the sensor input into digital bits or bytes or integers
Issue binary control commands	Issue control commands
Get data	Request information to be sent, including both measured data and metadata
Set data	Send information to be used or stored, including both values and metadata. This service is used for binary control commands, setpoint control commands, setting parameters, and writing descriptions

Activity/Service Name	*Activities/Services Provided*
Data set management	Group data values into sets for efficient transmittal. Data Sets can be created by database administrators either typing in lists of data or by browsing metadata databases and selecting the appropriate data items. Applications can also automatically create and delete Data Sets by accessing metadata databases.
Report control	Manage the reporting of Data Sets upon request, at a particular periodicity (e.g. integrity scan), and upon the occurrence of pre-specified events, such as data change (e.g. closed to tripped status), quality change (e.g. a problem causes data to be invalid), data update (e.g. an accumulator value is "frozen" periodically), or integrity scan mismatch (e.g. the integrity scan indicates a different status value from the value that was last reported).
Logging control	Manage logging and journaling of information, such as sequence of events
Substitution values	Manage the substitution of values if these are indicated in the Data Object classes
High speed messages	Handle special ultra-high-speed messaging to multiple destinations, typically for protective relaying
Select-Before-Operate Control	Implement the safety mechanisms used by most switch-related control commands. This procedure basically consists of: an originator of the control command first issuing a select of the control point, the receiver then performing a select and reporting the results back to the originator, the originator then issuing an execute command which the receiver performs only if it receives the execute command within a pre-specified time from the originator.
Time management	Handle the synchronization of time across all interconnected nodes
File transfer	Handle the transfer of files between entities, without treating them as data objects. This capability supports the uploading of new applications into the IEDs and other servers.

1.8 Contracts/Regulations

Identify any overall (human-initiated) contracts, regulations, policies, financial considerations, engineering constraints, pollution constraints, and other environmental quality issues that affect the design and requirements of the Function.

Contract/Regulation	*Impact of Contract/Regulation on Function*
Provide power system data and permit control of power system equipment	Requires data to be provided and control to be allowed

Policy	*From Actor*	*May*	*Shall Not*	*Shall*	*Description (verb)*	*To Actor*
Authorization	Regional System Operator			X	Authorize all control actions, either as pre-set parameters or as real-time commands	IEDs, Substation masters

Constraint	*Type*	*Description*	*Applies to*
Laws of physics	Natural	Power systems react to the laws of physics Communications media act according to the laws of physics and Claude Shannon	Power system actions Communications media and information encoding

2 Step by Step Analysis of Function

Describe steps that implement the function. If there is more than one set of steps that are relevant, make a copy of the following section grouping (Preconditions and Assumptions, Steps normal sequence, and Steps alternate or exceptional sequence, Post conditions)

2.1 Steps to implement function

Name of this sequence.

2.1.1 Preconditions and Assumptions

Describe conditions that must exist prior to the initiation of the Function, such as prior state of the actors and activities

Identify any assumptions, such as what systems already exist, what contractual relations exist, and what configurations of systems are probably in place

Identify any initial states of information exchanged in the steps in the next section. For example, if a purchase order is exchanged in an activity, its precondition to the activity might be 'filled in but unapproved'.

Actor/System/Information/Contract	***Preconditions or Assumptions***
Field equipment, IEDs, Substation master, data concentrator, SCADA system	Equipment, devices and systems must be installed and operational

2.1.2 Steps – Normal Sequence

Describe the normal sequence of events, focusing on steps that identify new types of information or new information exchanges or new interface issues to address. Should the sequence require detailed steps that are also used by other functions, consider creating a new "sub" function, then referring to that "subroutine" in this function. Remember that the focus should be less on the algorithms of the applications and more on the interactions and information flows between "entities", e.g. people, systems, applications, data bases, etc. There should be a direct link between the narrative and these steps.

The numbering of the sequence steps conveys the order and concurrency and iteration of the steps occur. Using a Dewey Decimal scheme, each level of nested procedure call is separated by a dot '.'. Within a level, the sequence number comprises an optional letter and an integer number. The letter specifies a concurrent sequence within the next higher level; all letter sequences are concurrent with other letter sequences. The number specifies the sequencing of messages in a given letter sequence. The absence of a letter is treated as a default 'main sequence' in parallel with the lettered sequences.

Sequence 1:

```
1.1 - Do step 1
1.2A.1 - In parallel to activity 2 B do step 1
1.2A.2 - In parallel to activity 2 B do step 2
1.2B.1 - In parallel to activity 2 A do step 1
1.2B.2 - In parallel to activity 2 A do step 2
1.3 - Do step 3
1.3.1 - nested step 3.1
1.3.2 - nested step 3.2
```

Sequence 2:

```
2.1 - Do step 1
2.2 – Do step 2
```

2.1.2.1 Steps for Direct Power Equipment Control by IEDs

An IED receives sensor data from a Potential Transformer (PT), or a circuit breaker IED issues a trip signal to a circuit breaker device.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
#	*Triggering event? Identify the name of the event.*[1]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.5.1*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*
1.1	Continuous or very frequent data retrieval	Power system equipment, including associated field device, PTs, and CTs	Monitor sensors	IED performs analog-to-digital and/or digital-to-digital conversions from sensor inputs, retrieving data from its associated power system equipment and from PT and CT sensors. IED then performs basic engineering conversions on the raw data, processes the information, and determines if any subsequent actions are needed based on limit checking and other process results	SensorDevice	IED	Raw sensor data	No: config issue Yes: QoS – – high speed 1-4 ms; retrieval from sensors must be synchronized with sending to other IEDs; access control, accuracy, precision, timing Yes: security – integrity, confidentiality may be an issue Minor issues related to data management Yes: constraints – legacy equipment	Inter-Field Equipment

[1] Note – A triggering event is not necessary if the completion of the prior step – leads to the transition of the following step.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
1.2	Processed data indicates further local action needed	IED	Send control commands	IED issues control commands to power system equipment, based on the results of processing the input data from the field	IED	Other IEDs or power system equipment, such as CircuitBreaker, VoltageRegulatorController, capacitor bank switches, LoadTapChangeController, RecloserDevice, etc	Signal data	See 1.1	Inter-Field Equipment

2.1.2.2 Steps for Local Interactions Among IEDs

A protection IED issues a trip command over a high speed LAN to a circuit breaker IED within a substation, based on its detection of different power system measurements, such as low frequency, current overload, etc.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
#	*Triggering event? Identify the name of the event.*[2]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.5.1*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*
2.1	Continuous monitoring	Power system equipment	SensorDevice monitoring	Each IED in the group monitors local power system equipment	Power system equipment	IEDs	Sensor data	See 1.1	Inter-Field Equipment
2.2	Fault in a feeder segment occurs	SensorDevice or IED	Fault detection	A fault occurs in a feeder segment. This fault is detected by one or more IEDs, including a protection IED in the substation.	SensorDevice or IED	IED	Fault sensor data	See 1.1	Inter-Field Equipment
2.3	Protection IED issues trip command	Protection IED	Trip command	The protection IED issues a trip command to the recloser IED. Using the mechanisms described in section 2.2.1, the recloser IED issues a trip command to its recloser.	Protection IED	Equipment	Trip command	See 1.1	Inter-Field Equipment

[2] Note – A triggering event is not necessary if the completion of the prior step – leads to the transition of the following step.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
2.4	Recloser trips	SensorDevice or IED	Monitor response to command	The recloser trips and this information is received by automated switch IEDs on the affected feeder.	SensorDevice or IED	IED	Control response sensor data	See 1.1	Inter-Field Equipment
2.5	IED internal analysis results – multiple iterations	One IED	Local IED response to fault	IEDs near faulted feeder segment communicate and determine which switches should be opened and which closed. This occurs a number of times, depending upon the results of the IED actions, the results of the recloser actions, and the parameter settings in the IEDs. Each IED performs its actions via the 2.2.1 process.	One IED	Other IEDs	Digital electric data	Yes: config issue – IEDs may be in distant locations, poor communications Yes: QoS – high speed 1 sec access, accuracy, precision, timing Yes: security – authentication, integrity, confidentiality, prevent denial of service Yes: data management among IEDs requires significant effort	Inter-Field Equipment

2.1.2.3 Steps for Computerized Field Systems Monitoring and Controlling via IEDs

Substation master coordinates the protection settings of substation IEDs based on requests from the SCADA system for different response patterns. For instance, different protection trigger levels are set for recloser responses if a storm is pending, or if reconfiguration of a feeder impacts the expected fault current level, or if DER generation levels could cause fuses to blow unnecessarily.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
#	*Triggering event? Identify the name of the event.*[3]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.5.1*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*
3.1	On-going monitoring of data by substation master	Multiple IEDs	Data monitoring	Substation master receives digital data from IEDs within a substation and along adjacent feeders. This data can be transmitted periodically or upon significant change of an analog value or upon status change	Multiple IEDs	Substation master	Digital electric data	Config: Many devices, some in the substation, some along feeders. QoS: accuracy and availability are crucial Security: authentication, integrity, and possibly confidentiality Data management: Could become very complex, ensure consistency Constraints: often compute and bandwidth constraints, some legacy systems	Deterministic Rapid Response Intra-Sub

[3] Note – A triggering event is not necessary if the completion of the prior step – leads to the transition of the following step.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
3.2	Request by SCADA to change protection settings	Substation master	Change settings	As requested by the control center SCADASystem, the substation master determines the appropriate settings for protective relays and RecloserDevice for a specific scenario (e.g. storm, changed feeder configuration)	Substation master	Protection and recloser IEDs	Settings	See 3.1	Deterministic Rapid Response Intra-Sub
3.3	Power system event with IEDs responding	IEDs	Sequence of events recording	A power system event occurs, to which the local IEDs respond. They then report their sequence of events to the substation master for inclusion with disturbance records.	IEDs	Substation master	IED SOE	See 3.1	Deterministic Rapid Response Intra-Sub
3.4	Regional System Operator initiates trip of breaker	Substation master	Select before operate (SBO) command	The substation master ensures that a control request from the control center is authorized, then passes the request to the circuit breaker IED for execution	Substation master	Circuit breaker IED	SBO control request	See 3.1	Deterministic Rapid Response Intra-Sub

2.1.2.4 Steps for DER Management System Monitoring and Control of DER Devices

The owner of the DER device decides to reduce his load on the utility EPS by increasing generation. The DER operator implements this decision by setting new parameters in the DER management system. (These are manual actions by persons.) As an automated result, another generator is started by the DER management system, synchronized with the local EPS, and interconnected.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
#	*Triggering event? Identify the name of the event.*[4]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.5.1*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*
4.1	DEROwner decides to reduce load	DEROwner	Owner decision	DEROwner contacts (calls, e-mails, alarms) DEROperator that additional energy from DER generation is needed.	DEROwner	DEROperator	Call by person	None	Special
4.2	DEROperator enters new parameters	DEROperator	Establish parameters	DEROperator sets new parameters for DER generation output in the DERManagementSystem.	DEROperator	DERManagementSystem	DER data entry	User interface	User Interface

[4] Note – A triggering event is not necessary if the completion of the prior step – leads to the transition of the following step.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
4.3	Start command	DERManagementSystem	Start DER	DERManagementSystem issues start command to a DERDevice.	DERManagementSystem	DERDevice	DER start-up command	Config: A few DERDevices in campus-like area. QoS: accuracy and availability are crucial. Protocol "services" are required Security: authentication, integrity, and confidentiality Data management: Report and log data Constraints: No established standard protocols	DER Monitoring and Control
4.4	DER Unit started	DERDevice	Synchronization	DER Unit starts and synchronizes with the Local EPS, and reports success and current operating measurements to DERManagementSystem	DERDevice	DERManagementSystem	DER reporting	See 4.3	DER Monitoring and Control

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
4.5	On-going DERDevice operations	DERDevice	Monitoring DER	DERDevice reports current operating measurements to DERManagementSystem for operational information as well as historical and statistical information	DERDevice	DERManagementSystem	DER historical and statistical records	See 4.3	DER Monitoring and Control
4.6	Environmental limit reached	DERManagementSystem	Environmental limit	DERManagementSystem calculates that a diesel generator has reached its daily (assigned) limit of emissions, and issues a stop command	DERManagementSystem	DERDevice	DER stop command	See 4.3	DER Monitoring and Control
4.7	DERDevice stops	DERDevice	Stop DER	DERDevice stops and shuts down. It reports back to the DERManagementSystem with its latest data	DERDevice	DERManagementSystem	DER reporting	See 4.3	DER Monitoring and Control
4.8	DERDevice reports received	DERManagementSystem	DER reports	DERManagementSystem provides DERDevice data to DEROperator via a User Interface	DERManagementSystem	DEROperator	User display	User interface	User Interface

2.1.2.5 Steps for Monitoring and Control by SCADASystem

Distribution operations SCADA system monitors and controls power system equipment via a multitude of mechanisms.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
#	*Triggering event? Identify the name of the event.*[5]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.5.1*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*

[5] Note – A triggering event is not necessary if the completion of the prior step – leads to the transition of the following step.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
5.1	Establish an association between SCADASYSTEM and RTU and/or IED	SCADASystem and REMOTETERMINALUNIT/IED	Establish association	Using an interactive process between an RTU or IED and a SCADASystem, an association is established. This interactive process varies from protocol to protocol, but essentially entails setting up what data is available and what data is to be sent under what conditions. In some protocols, many of the steps are manual, while in others they are almost entirely automatic.	SCADASystem and REMOTETERMINALUNIT/IED	REMOTETERMINALUNIT/IED and SCADASystem	Association	Config: 10's to 1000's of field IEDs. May act through data concentrators or substation masters. Acquisition within 1 second QoS: accuracy and availability are crucial. Protocol "services" are required Security: authentication, integrity, and possibly confidentiality Data management: Vast amounts of data requiring acquisition and subsequent transmittal to other users. Consistency of data is important Constraints: Many legacy systems with legacy protocols and limited capabilities	Deterministic Rapid Response Inter Site

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
5.2	Status change occurs in power equipment	IED which is sensing power system equipment	Detect status change	A status change occurs in some power system equipment. This status change is "immediately" sent (usually within 1 second) to the SCADASystem. Depending upon the communication "services", the status value can be sent periodically, or can use the "report-by-exception" service, which sends a status value only if it changes	IED which is sensing power system equipment	SCADASystem	Status change	See 5.1	Deterministic Rapid Response Intra-Sub
5.3	"Significant" change in a measurement value	REMOTETERMINALUNIT which is sensing power system equipment	Detect significant measurement change	A significant change occurs in a measured value. (Significant implies it exceeds some pre-established limit.) This changed value is sent according to pre-established protocol services: e.g. *report-by-exception* sends it immediately (within 1 to 2 seconds), while *periodically* sends it when the time period elapses. The protocol also determines what information is included, such as timestamp, quality code, etc.	REMOTETERMINALUNIT which is sensing power system equipment	SCADASystem	Measurement change	See 5.1	Deterministic Rapid Response Intra-Sub

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
5.4	SCADA issues control command	SCADASystem	Issue control command	Either an operator or an application issues a control command through the SCADASystem to an REMOTETERMINAL UNIT or IED. These control commands are typically immediately implemented by sending a signal to the power system equipment	SCADASystem	REMOTETERMINALUNIT or IED which initiates signals to power system equipment	Control command	See 5.1	Deterministic Rapid Response Intra-Sub
5.5	SCADA sends parameter settings	SCADASystem	Set parameters	Either an operator or an application sends a parameter setting through the SCADASystem to an REMOTETERMINAL UNIT or IED. These parameter settings may be stored for later use or may be used immediately to initiate a signal to the power system equipment, such as a raise or lower control command	SCADASystem	REMOTETERMINALUNIT or IED	Parameter setting	See 5.1	Deterministic Rapid Response Intra-Sub
5.6	SCADA requests specific data	SCADASystem	Request data	Either an operator or an application requests specific data to be sent to the SCADASystem from an REMOTETERMINAL UNIT or IED.	SCADASystem	REMOTETERMINALUNIT or IED	Request	See 5.1	Deterministic Rapid Response Intra-Sub

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
5.7	Sequence of Events log	REMOTETERMINALUNIT or IED	Transmit sequence of events records	An REMOTETERMINALUNIT or IED has collected Sequence of Events log and initiates its transmittal to the SCADASystem	REMOTETERMINALUNIT or IED	SCADASystem	SCADA SOE	See 5.1	Deterministic Rapid Response Intra-Sub

2.1.3 Steps – Alternative / Exception Sequences

Describe any alternative or exception sequences that may be required that deviate from the normal course of activities. Note instructions are found in previous table.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments

2.1.4 Post-conditions and Significant Results

Describe conditions that must exist at the conclusion of the Function. Identify significant items similar to that in the preconditions section.

Describe any significant results from the Function

Actor/Activity	***Post-conditions Description and Results***

Actor/Activity	*Post-conditions Description and Results*

2.2 Architectural Issues in Interactions

Elaborate on all architectural issues in each of the steps outlined in each of the sequences above. Reference the Step by number..

Microsoft Excel Worksheet

2.3 Diagram

For clarification, draw (by hand, by Power Point, by UML diagram) the interactions, identifying the Steps where possible.

See diagrams in Narrative section.

3 Auxiliary Issues

3.1 References and contacts

Documents and individuals or organizations used as background to the function described; other functions referenced by this function, or acting as "sub" functions; or other documentation that clarifies the requirements or activities described. All prior work (intellectual property of the company or individual) or proprietary (non-publicly available) work must be so noted.

ID	Title or contact	Reference or contact information
[1]	Hundreds of utility operators, SCADA and equipment vendors, consultants, and system specifications that I have read and written over the last (gulp) 30 years.	Frances Cleveland
[2]		

3.2 Action Item List

As the function is developed, identify issues that still need clarification, resolution, or other notice taken of them. This can act as an Action Item list.

ID	Description	Status
[1]		
[2]		

3.3 Revision History

For reference and tracking purposes, indicate who worked on describing this function, and what aspect they undertook.

No	Date	Author	Description
1	October 23, 2003	Frances Cleveland	Revision 1
2	January 25, 2004	Frances Cleveland	Revision 2 to put into final template and make minor updates