

# openPG

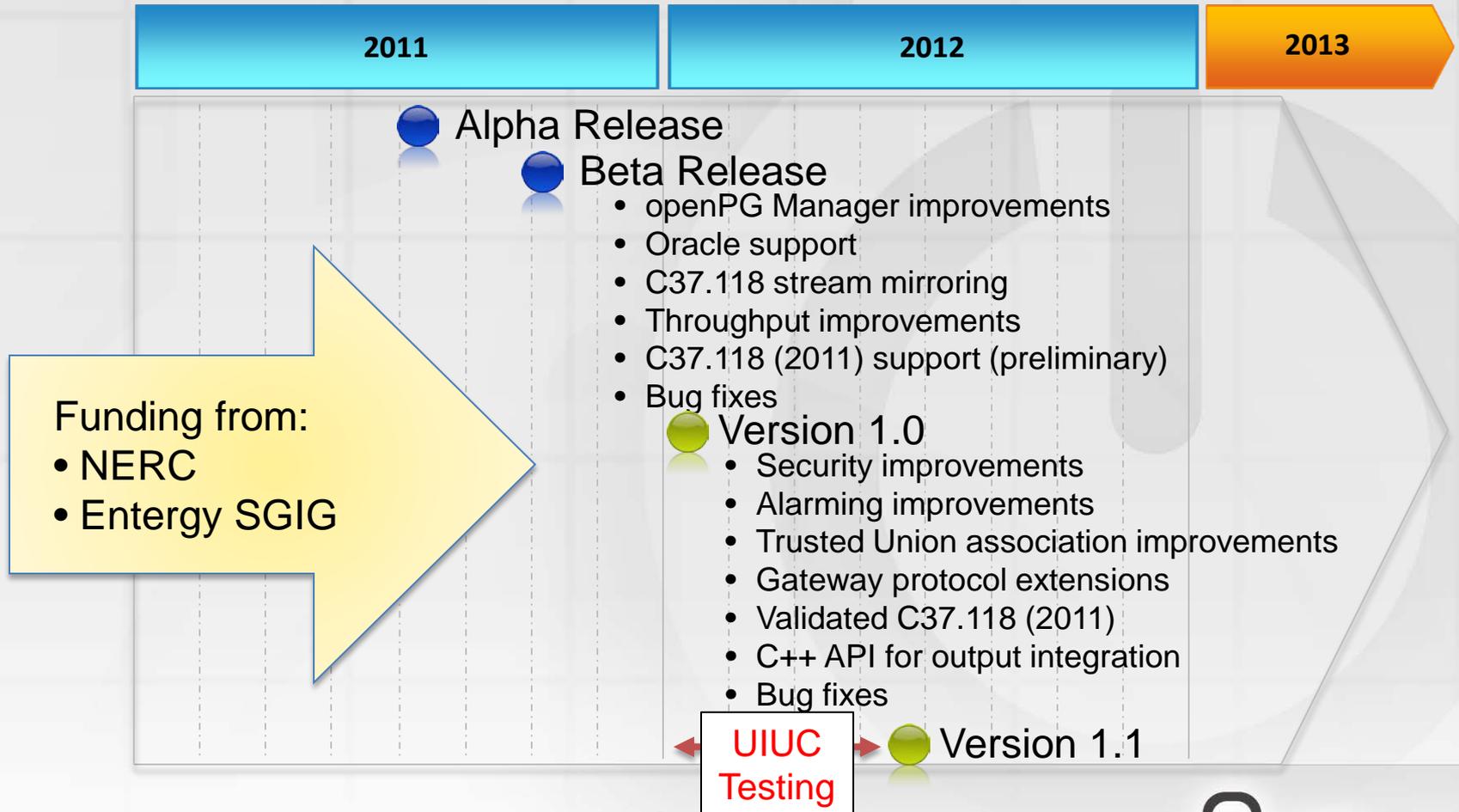
## Phasor Gateway

October 13, 2011

James Ritchie Carroll, GPA

# openPG Releases

See: [openPG.codeplex.com](http://openPG.codeplex.com)



# A Phasor Gateway

- **What are functions of a gateway?**
- **What are gateway specifications?**
- **How does a gateway exchange data?  
Has this format been standardized?**
- **How do PDC's exchange data with gateways?**
- **How do gateways interact with a national registry?**

Questions from Vikram Budhraja, August 2011

# What's a gateway for?

- **It makes the job of exchanging phasor data easier**
- **It is a necessary edge device, to protect critical infrastructure and facilitate security compliance**

# Authorize Measurements for Publication

openPG Manager

Home Local Properties Publication Subscription Inputs Outputs

Manage Subscriber Measurement Access

For a particular Subscriber

Allowed Measurements

Available Measurements

<input type="checkbox"/>	Point Tag	Signal Reference
<input type="checkbox"/>	GPA_TESTSTREAM!OS:ST1	STAT:35
<input type="checkbox"/>	GPA_TESTSTREAM!OS:ST10	STAT:44
<input type="checkbox"/>	GPA_TESTSTREAM!OS:ST11	STAT:45
<input type="checkbox"/>	GPA_TESTSTREAM!OS:ST12	STAT:46
<input type="checkbox"/>	GPA_TESTSTREAM!OS:ST13	STAT:47
<input type="checkbox"/>	GPA_TESTSTREAM!OS:ST14	STAT:48
<input type="checkbox"/>	GPA_TESTSTREAM!OS:ST15	STAT:49
<input type="checkbox"/>	GPA_TESTSTREAM!OS:ST16	STAT:50
<input type="checkbox"/>	GPA_TESTSTREAM!OS:ST17	STAT:51
<input type="checkbox"/>	GPA_TESTSTREAM!OS:ST18	STAT:52
<input type="checkbox"/>	GPA_TESTSTREAM!OS:ST19	STAT:53

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Allowed Groups

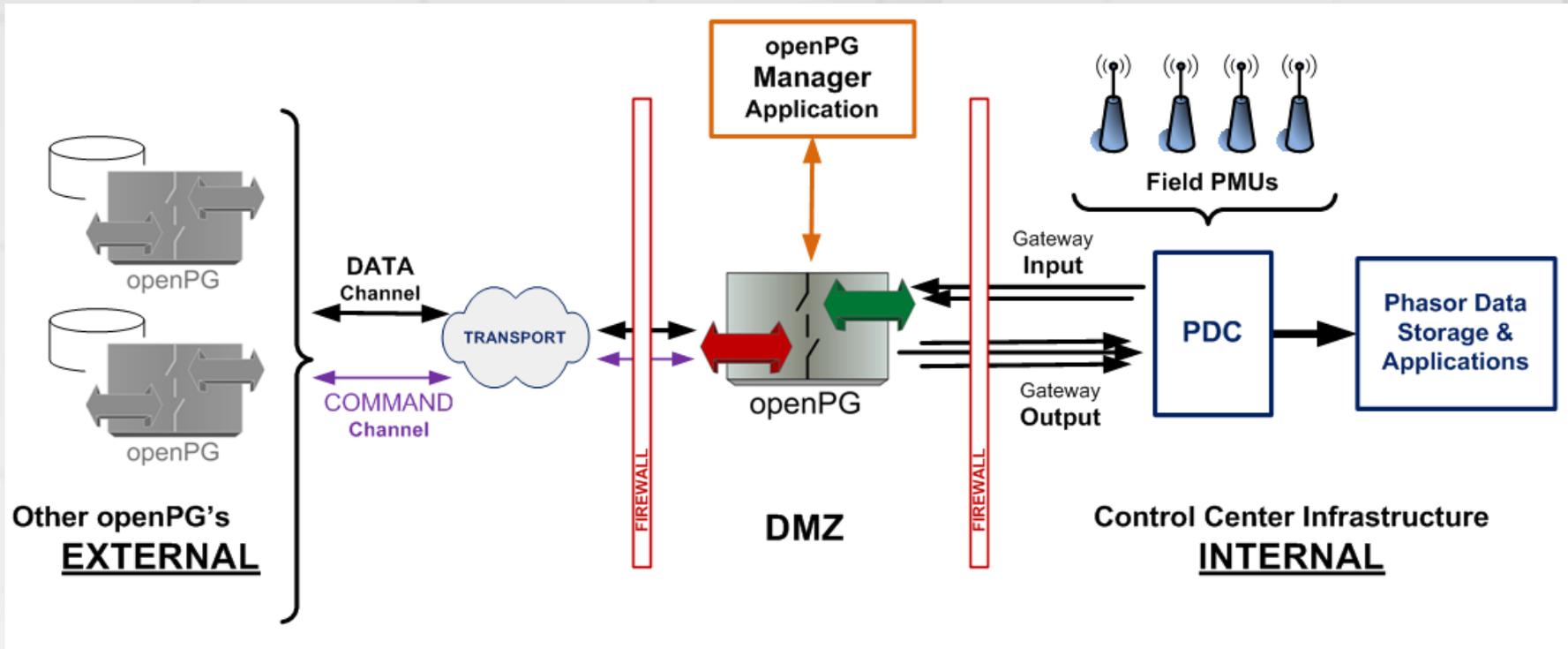
Denied Groups

Allowed Measurement Groups Available Measurement Groups Denied Measurement Groups

# Frame-based protocols don't always scale well.

- In theory, C37.118-2005 can scale to the 64K UDP packet limit.
- In practice, UDP has been found to frequently be throttled to 16K packet sizes – around 130 PMUs.
- 61850-90-5 includes more overhead than C37.118
- **Solution**
  - Add configuration complexity through use of multiple output streams
  - Implement the a phasor gateway which has been designed for very-high volume phasor traffic

# Typical Phasor Gateway Implementation



# What's a gateway for?

## Business Case for the Open Phasor Gateway



The openPG provides required security isolation as it reduces operational costs

### Application Profile

The openPG is a back office system that is used to securely send and receive high sample rate synchrophasor data with owners of other openPGs.

### Hardware

The openPG executes on standard server hardware. As a massively threaded application, it effectively utilizes all CPU resources presented to it. A production openPG is not intended for implementation in a virtualized environment.

### Required OS and Services

The openPG is a Microsoft .net application and is intended for deployment using Windows Server 2005 or 2008. However, the openPG will run under other Windows operating systems.

### Business Needs

Recent growth in the amount of phasor information and the need to share it among grid operators is a call for an appliance that:

- Creates a hardened security buffer between critical internal and external systems.
- Provides high-quality encryption to protect the confidentiality of reliability and market sensitive BES data.
- Facilitates and reduces the cost of phasor data exchange.

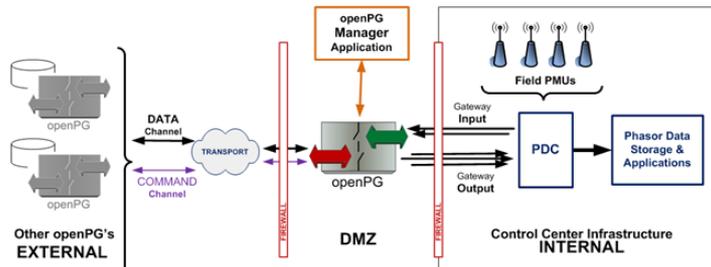
This need was anticipated by DOE in 2008 as they funded the development of the NASPI net technical specification. This specification called for an appliance named the phasor data gateway. The openPG is an implementation of this gateway for real-time phasor data exchange.

### openPG Overview

The Phasor Gateway provides an easy-to-configure interface to other phasor information systems. Development of the openPG has been funded by NERC.

The openPG:

- Only exchanges data with other openPGs where a trusted union has been established.
- Automatically discovers the phasor measurements that have been made available by other openPGs and allows the selective subscription to these measurement points.
- Provides tools for administrators to limit the phasor data that is available for subscription by a specific openPG.
- Supports strong encryption of the data exchanged between gateways.



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See: [openPG.codeplex.com](http://openPG.codeplex.com)

## Business Case for the openPG



### Benefits

Using the openPG rather than standard protocols, such as IEEE C37.118, has the advantage of:

- Improving security and reducing bandwidth by only exchanging the measurement points that are needed.
- Simplified configuration management through automated metadata exchange and ability to easily rename imported data points.
- Reduced latency for most phasor data since the concentration step of a PDC is not required.
- Scalability and extensibility.

**Compliance Assurance.** As a security device, the openPG is intended to be installed at the edge of a security perimeter, and its functionality is purposely limited to secure communication with other openPGs. The openPG provides:

- **NERC Data Sharing** — The openPG promotes BES reliability improvement by providing an easy and secure way to exchange phasor data with others — as an IEC node does today. Phasor data exchange can only occur between pairs of gateways that have established trusted unions.
- **Change Testing** — The openPG improves change resiliency and provides the tools for operation staff to quickly validate phasor information system changes.
- **Change Logging** — To meet CIP requirements all configuration changes to the openPG are logged.
- **Operations Logging** — The openPG includes an operational log historian that records a collection of key gate-

way operating statistics every 10 seconds.

- **Access Control** — Administrator access credentials can be maintained in external systems, such as MS Active Directory, or can be stored locally in encrypted configuration files.
- **System Currency** — The openPG is easy to test, update and patch as new versions are released.

**Data Confidentiality.** The openPG utilizes best practice encryption with frequent key change to provide the highest levels of data confidentiality.

**Configuration Flexibility and Efficiency.** The openPG reduces costs by making phasor data exchange easy to manage.

- **Exchange of Gateway Meta Data** — The openPG sends its configuration information to other trusted openPG's on request. Measurements are assigned a Globally Unique Identifier (GUID) so that the common name to reference the point can be changed as needed by each gateway user. This feature allows the gateway to assign or update names to points sent or received without impacting gateway operator or downstream applications.
- **Quick Additions of New Points** — Each sending gateway provides a list of available points to other openPGs. Selecting a new point for subscription just requires a few mouse clicks.
- **Configuration Alignment** — The ability to dynamically update configuration information results in faster, lower cost openPG operation. As an openPG owner makes changes

to measurement metadata, these changes are made known to all other connected gateways.

- **Data Transfer Efficiency** — Data is transferred among gateways on a point-by-point basis with each point transferred requiring only 9 bytes through use of GPA's Gateway Exchange Protocol.
- **Open Source Reduces Total Cost** — Redistribution and modifications of the openPG are allowed without royalties or licensing costs. Thorough community review lowers risk and improves quality. The openPG is released under the Eclipse Public License.

**Low Latency.** The openPG can receive multiple input data streams and forward this phasor data to the specified gateways without the need for data concentration delays.

**High Availability.** The openPG is designed to be deployed as a service within a clustered server environment.

**High Quality Solution.** The openPG is an object oriented system that is open source with many eyes on code quality.

**System Integration.** The openPG is designed to leverage the full suite of input and output adapters developed for the openPDC. As support for new protocols are developed for the openPDC, these improvements will dynamically be available to the openPG as well.

**Future Proofing.** As an open source product, there is no vendor lock-in with the openPG. Any open source community improvements to GPA's time series library are seamlessly incorporated into new openPG releases. The openPG is available for download at: <http://openPG.codeplex.com>

May 2011

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# What are gateway specifications?

- **NASPInet Gateway Functional Specifications**
- **Detailed Requirements and Phasor Gateway Metrics, *Entergy SGIG Project***

# openPG-NASPI Inet Alignment

NASPI Inet Gateway Key Requirement	openPG
Serve as the sole access to the Data Bus	<b>Aligned.</b> The openPG is the sole access point for exchange of phasor information with other openPGs with establishing trusted gateway unions as a key design element.
Facilitate and administer registration of PG_REQUESTER's PMU, PDC, and signals	<b>Aligned.</b> The openPG configuration database contains metadata on the phasor measurements. An openPG downloads the metadata for points it is authorized to receive from other openPGs.
Facilitate and administer the subscription and publishing of phasor data	<b>Aligned.</b> The openPG supports both publishing and subscription of phasor data.
Monitor data integrity	<b>Aligned.</b> Each block of points transferred by the openPG contains checks to assure data integrity.
Manage traffic priority through the PG according to service classes	<b>Not Aligned.</b> All data exchanged by the openPG is in the single service class of "critical real-time data".
Provide logging of data transmission, access controls, and cyber security for analysis of all anomalies	<b>Aligned.</b> The openPDC produces both configuration and operational logs
Provide application programming interfaces (APIs) for interfacing with PG_REQUESTER systems and applications.	<b>Aligned.</b> The openPG is extensible by the user through development of new input and output adapters.

# How do gateways exchange data?

- **Today, there is no standard for gateway-to-gateway data exchange.**
- **GPA has created one for the openPG – nominally 9 bytes.**

*Data exchange efficiency is among the most important design considerations for a phasor gateway.*

# openPG - Gateway Exchange Protocol

- **Point ID** – A 16 bit integer that points to a GUID point identifier that that's provided in the command channel (2 bytes)
- **Time** – The milliseconds from an absolute time measurement provided in the command channel (2 bytes)
- **Value** – A 32 bit floating point real number (4 bytes)

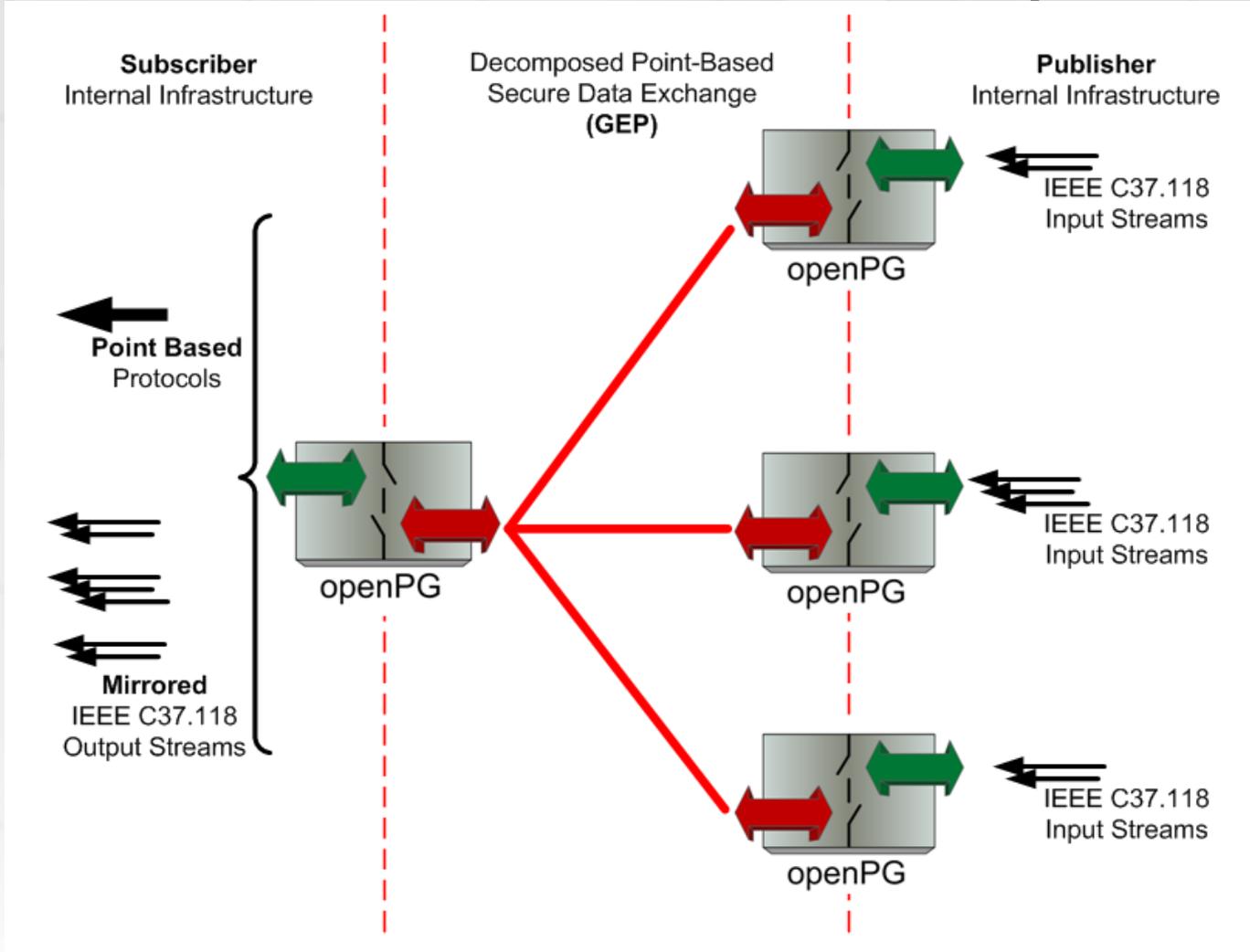
*Note: Version 1.0 of the openPG will support additional data types.*

- **Flags** – Single bit flags that are inclusive of C37.118 data quality flags (1 byte) that includes a flag to allow for full resolution time (which adds 6 bytes)

# How does the openPG exchange data with PDCs (or other systems)?

- **Gateway Inputs**
  - All standard phasor protocols
- **Gateway Outputs**
  - Gateway Protocol
  - IEEE C37.118 (2005 or 2011)
  - ADO Adapter for SQL Server
  - Custom Interfaces

# Mirrored C37.118 Output



# openPG Custom Interfaces

**Solution 1** – Use the openPG API to allow the application to consume GEP data

A C++ API will be provided with Version 1.0 to facilitate integration with systems that cannot accommodate .NET

**Solution 2** – Use the openPG adapter template to develop a custom output or action adapter

- **Read configured list of desired points** (provided by openPG Manager extension)
- **Points are received by adapter on change**
- **Provide data to a service and port in custom format**

# How do gateways interact with Registries?

- **The openPG is registry indifferent**
  - Subscribing openPG nodes are provided configuration data from publishing nodes
  - openPG provides easy-to-configure name translation services
  - openPG can easily be integrated with enterprise data modeling systems – or a regional naming service

# Edit Measurement Meta Data

openPG Manager

Current Node: Default

Home Local Properties Publication Subscription Inputs Outputs Monitoring Adapters

Manage Measurements

Point Tag \* GPA\_TESTSTREAM!IOS:ST1 Device SHELBY

Signal Reference \* TESTSTREAM!IOS-ST1 Measurement Type Statistic

Alternate Tag Historian STAT

Description Test Stream Statistic for Number of c  Internal  Subscribed

Adder \* 0  Enabled

Multiplier \* 1 Measurement GUID 96f3727f-9bdd-484d-8c50-91ec5ca85224

Delete Clear Search

ID	Description	Internal	Subscribed
STAT:35	Test Stream Statistic for Number of discarded measurements reported by outp	<input checked="" type="checkbox"/>	<input type="checkbox"/>
STAT:44	Test Stream Statistic for Number of published frames reported by the output s	<input checked="" type="checkbox"/>	<input type="checkbox"/>
STAT:45	Test Stream Statistic for Boolean value representing if the output stream was c	<input checked="" type="checkbox"/>	<input type="checkbox"/>
STAT:46	Test Stream Statistic for Minimum latency from output stream, in milliseconds,	<input checked="" type="checkbox"/>	<input type="checkbox"/>
STAT:47	Test Stream Statistic for Maximum latency from output stream, in milliseconds,	<input checked="" type="checkbox"/>	<input type="checkbox"/>
STAT:48	Test Stream Statistic for Average latency, in milliseconds, for data published fr	<input checked="" type="checkbox"/>	<input type="checkbox"/>
STAT:49	Test Stream Statistic for Number of clients connected to the comm and channe	<input type="checkbox"/>	<input type="checkbox"/>
STAT:36	Test Stream Statistic for Number of received measurements reported by the ou	<input type="checkbox"/>	<input type="checkbox"/>
STAT:37	Test Stream Statistic for Number of expected measurements reported by the o	<input type="checkbox"/>	<input type="checkbox"/>
STAT:38	Test Stream Statistic for Number of processed measurements reported by the i	<input type="checkbox"/>	<input type="checkbox"/>
STAT:39	Test Stream Statistic for Number of measurments sorted by arrival reported by	<input type="checkbox"/>	<input type="checkbox"/>
STAT:40	Test Stream Statistic for Number of published measurements reported by outp	<input type="checkbox"/>	<input type="checkbox"/>
STAT:41	Test Stream Statistic for Number of downsampled measurements reported by	<input type="checkbox"/>	<input type="checkbox"/>
STAT:42	Test Stream Statistic for Number of missed sorts by timeout reported by the o	<input type="checkbox"/>	<input type="checkbox"/>
STAT:43	Test Stream Statistic for Number of frames ahead of schedule reported by the	<input checked="" type="checkbox"/>	<input type="checkbox"/>
DEVARCHIVE:240	9Mile-Waterford3 Line +SV + Voltage Phase Angle	<input checked="" type="checkbox"/>	<input type="checkbox"/>
DEVARCHIVE:242	9Mile-Waterford3 Line +SI + Current Phase Angle	<input checked="" type="checkbox"/>	<input type="checkbox"/>

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Defaults assigned based on input or exchange data

Fields can be edited to perform name translation  
-- as published  
-- as subscribed

Search and Select

# DOE SIEGate Project

**SIEGate is a security-centric edge-device for all types of operating data that**

- Resists cyber attacks
- Preserves data integrity and confidentiality
- Meets real-time performance requirements



# SIEGate High Level Requirement Categories

- **Operational**
  - Data Classes
  - QoS/Performance
  - Availability
  - Scalability
- **System Integration**
  - Data Interfaces
  - Secure Logging
  - Alarming and Notifications
  - Interoperability
- **Security**
  - Compliance
  - Administrator Access
  - Data Security
  - Key Management
  - Failure Management
- **Administrative**
  - Configuration
  - Monitoring
  - Backup and Restore