

DOE/OE Transmission Reliability Program

Data Validation & Conditioning

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CERTS

CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Presentation

- Introduction of Project
- Project Status
- Overview of Bad Data Detection Algorithms – 6 Modules
- Overview of Data Validation Prototype
- Overview of Error Simulation Utility



The Problem

- Phasors are well known to engineers ...
but synchrophasors are not
 - Synchrophasor value dependencies
 - Precise timing source, algorithms, & hardware
 - Systems dependent on real-time communications
 - Delay (latency), bandwidth, errors, & dropouts
 - Need comparability with established systems (SCADA)
 - Wide area, high-speed – faster actions
- ➔ Need assurance measurements are correct and...
- ➔ Detect and fix data problems



Introduction

- Data Validation and Conditioning Project
 - RFP issued in June 2012
 - Awarded to EPG in December 2012
 - Completion by August 2014



Objective

- **Develop, test and prototype various methods for conditioning and validating real-time synchrophasor data**
 - Applicable to SGIG projects
 - Usable in deployed architectures
 - Include consideration of design & deployment
- **Output includes cleaned data & quality flags**



Project Plan

PHASE 1

**Survey, Conceptual Design
& Prototype Development**



**Review Existing SGIG Systems
Completed May 2013**



**Best Practice Recommendations
Completed June 2013**



**Research, Design, Develop and
Test Prototype
Completed March 2014**

PHASE 2

Prototype Demonstration



**Develop Error Simulation
Utility
Completion May 2014**



**Data Validation Prototype
Demonstration
Completion June 2014**

PHASE 3

**Functional Specifications of
the Data Validation System**



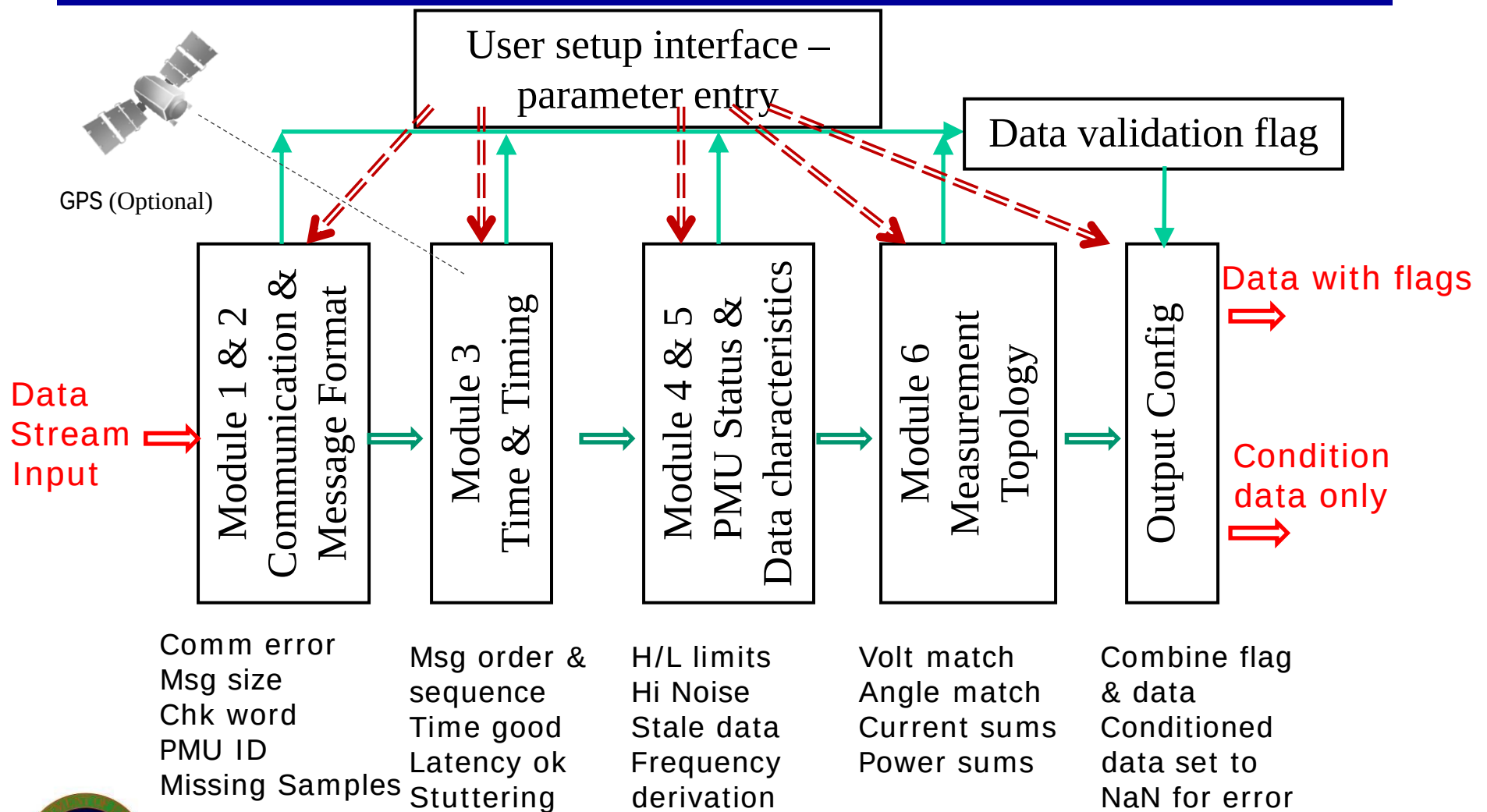
**Document Key Lessons Learned
Completion August 2014**



**Functional Specification
Completion September 2014**

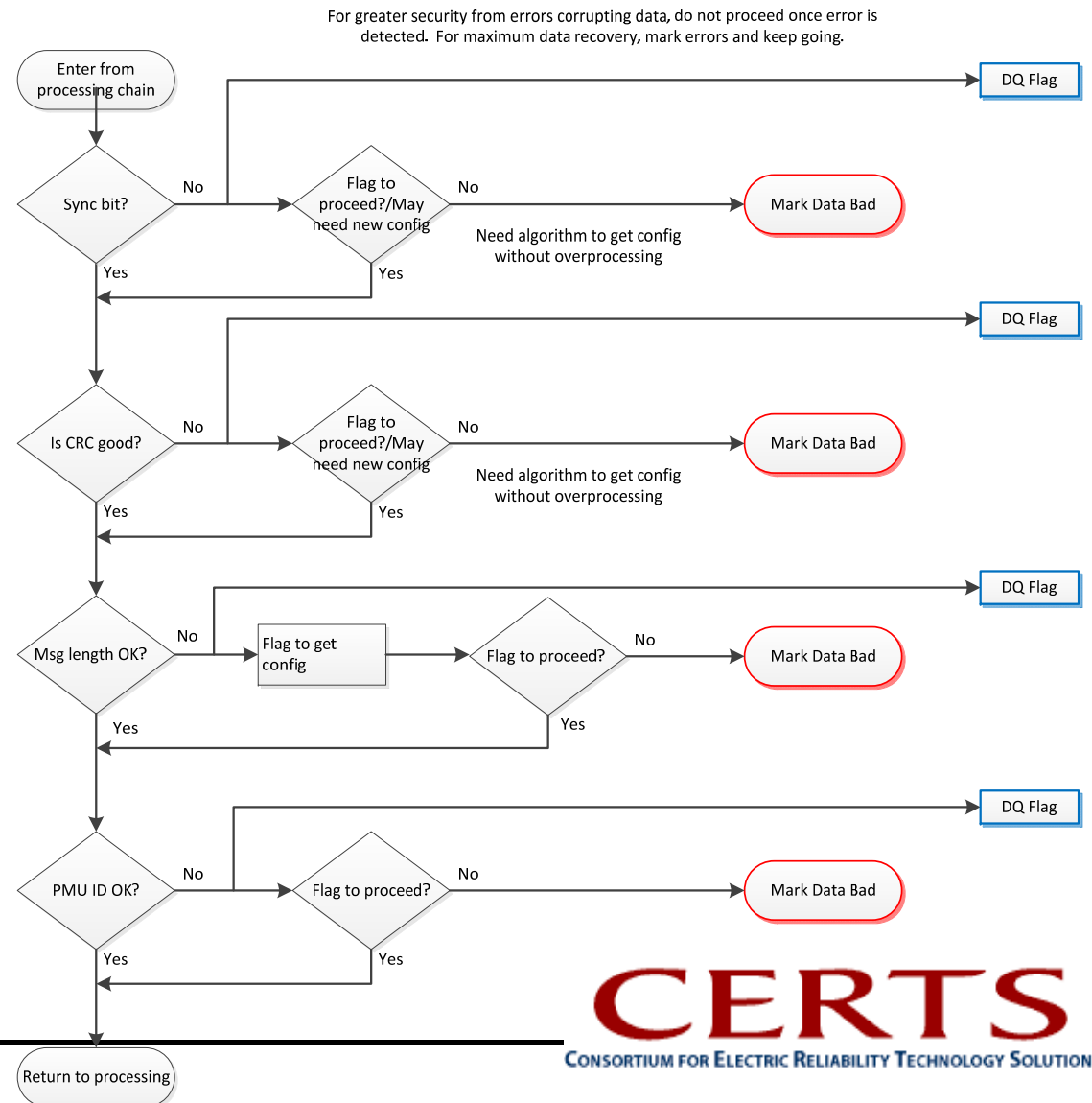


Algorithms Process & Stages – 6 Modules



Each Stage Has a Detailed Algorithm

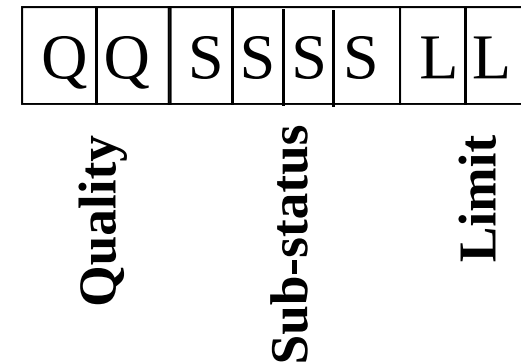
- Example of message level errors
 - Format Error
 - CRC Error
 - Sample Size Error
 - PMU ID Error
 - New/Removed PMU/Signal Detection



Data Quality Flag & Output

- Data quality flag – 8 bit

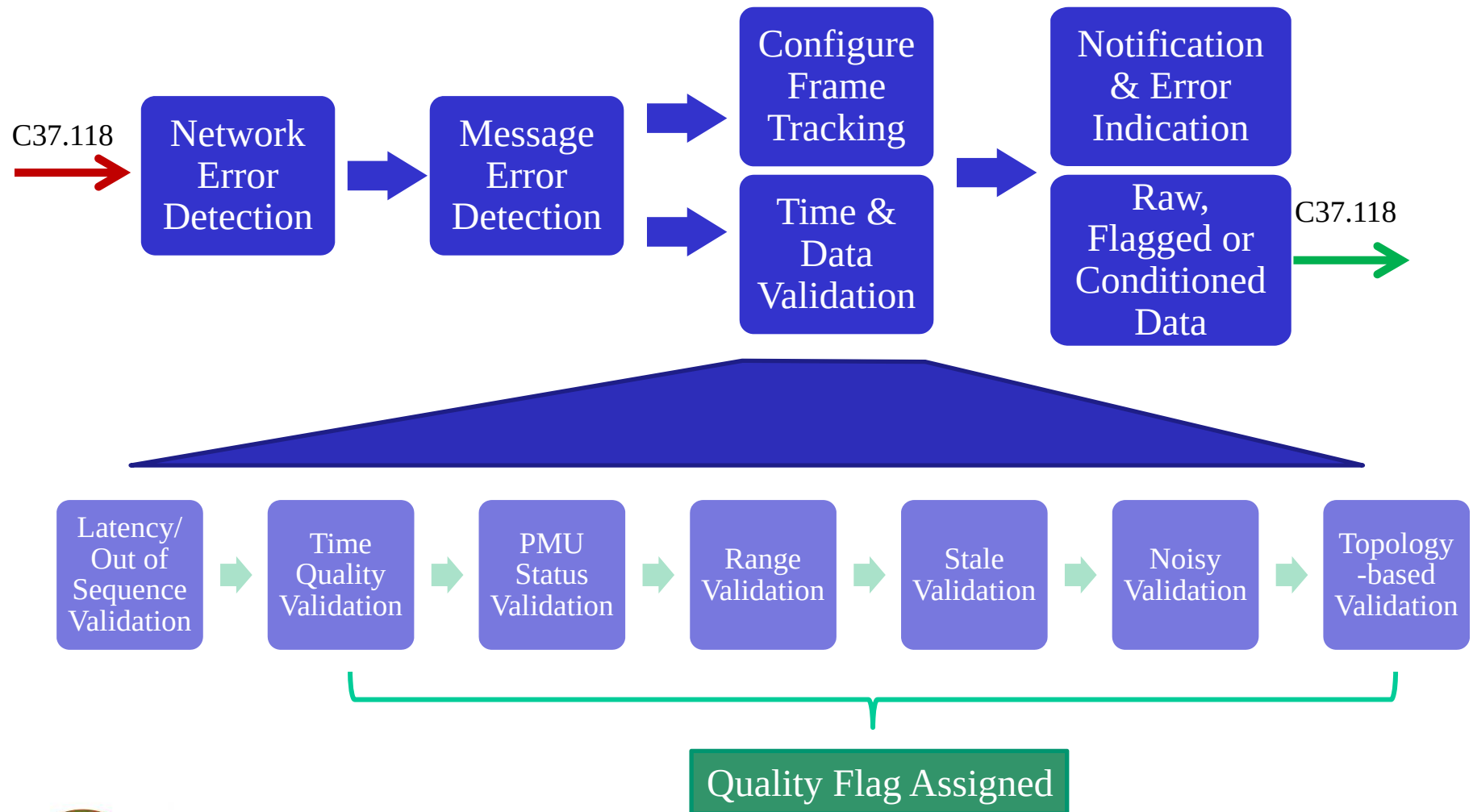
- Flag for each value
 - Phasor magnitude & angle
 - Frequency & ROCOF
- Can be sent in 118 stream



- Quality – good, bad, uncertain, reserved
- Sub-status – reason for the quality indication
- Limit – value at H/L limit, cannot move, or ok
- Bad data set to NaN to prevent further use
- Dual outputs
 - Output partially conditioned with flags (only fatal errors cleaned)
 - Output with fully conditioned data



PDVC Prototype Workflow



PDVC – Sample Setup Screenshot

■ Example – Time Validation

- Deviation
- Shifting
- Latency
- Data Rate

PDVC Data Manager Configuration:

General	Time Validation	PMU Status Validation	Value Validation	Topology Validation
Deviation Limit from System Time:		5 Seconds		
☒ Enable Sample Shift Detection				
Forward Shift Limit:		1 Samples		
Backward Shift Limit:		1 Samples		
☒ Enable Latency Detection				
Forward Shift Resolution:		2.000 Seconds		
Backward Shift Resolution:		2.000 Seconds		
☒ Enable Data Frame Interval Inconsistency Detection				
Data Frame Interval Inconsistency Assertion Delay:		1.000 Seconds		



PDVC – Sample Result

File Configuration Monitoring Account Help

Input Monitoring

- Input System
 - TEST
 - TEST.PMU1
 - Status
 - V21
 - V22
 - C21
 - Frequency
 - Latency
 - TEST.PMU2

PMU Values PMU Plot

Input PMU Characteristics

ID Code: 9999
 Station Name: PMU1
 Host Machine Date/Time: 02-27-2014 09:42:24.182
 PMU Data Time: 02-27-2014 09:42:24.166

Index	Signal Name	Signal Type	Value	Quality C	Data Quality
1 0	Status	Status	0x00C0 (Good Data)	0xC0	Good
2 1	V21	Voltage	51.9615 kV / 57.295...	0x64 0x64	Uncertain, Topology Validation Failure/Uncertain...
3 2	V22	Voltage	536.936 kV / -57.295...	0x56 0xC0	Uncertain, Engineering Unit Exceeded High Limit/...
4 3	C21	Current	500 A / -42.9718 De...	0x64 0x64	Uncertain, Topology Validation Failure/Uncertain...
5 4	Frequency	Frequency	59 Hz / 0 Hz/s	0xC0 0x...	Good/Good
6 5	ToA Latency	Analog	0.000963004 Seconds	0xC0	Good

Refresh

☒ Auto Refresh Reconnect

Refresh Interval 1 Seconds

Sort Signal lists by: ALL Signals Voltage Magnitude: Convert to L-L kV

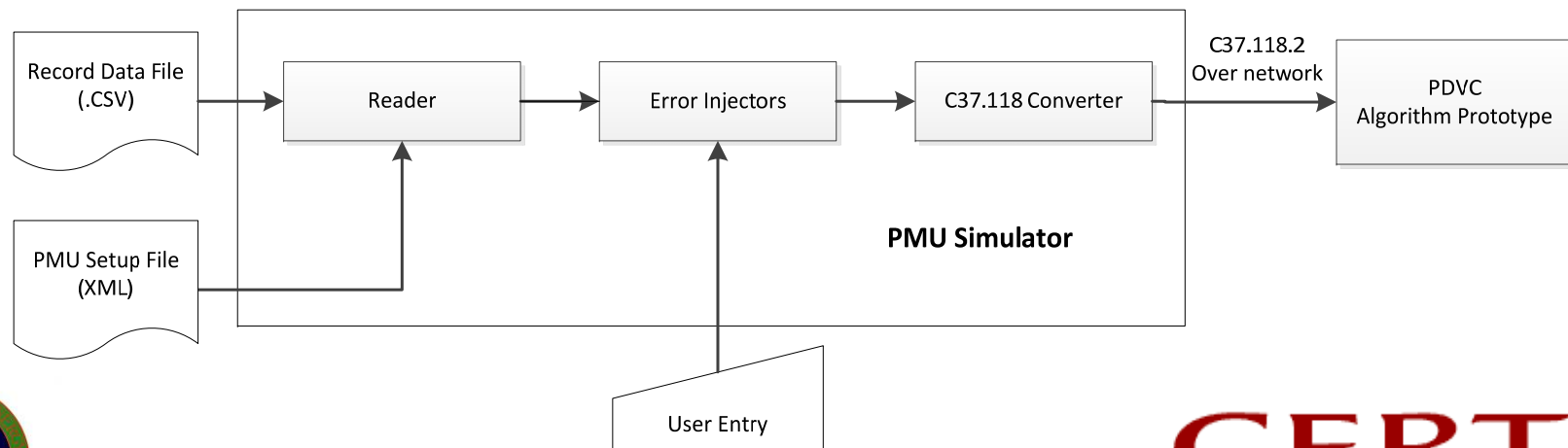
Measurement Values

Measurement Quality



Error Simulation Utility (PMU Simulator)

- Data Source
 - Recorded real data in CSV file format
 - Real-time simulation
- Functionality
 - Replay or Simulate real-time C37.118 stream
 - Inject errors at protocol level, PMU level, and measurement level
 - Manage PMU/Signal and communication options



PMU Simulator Layout

PMUSimulatorC:/Users/mo/proj_phasor/PDCSolution/debug/2pmus.xml (Copyright Electric Power Group)

File Help **1. Menu**

PMU/Signal Configuration

PMU And Channels

- PMU Input
 - PMU1
 - Status
 - V21
 - V22
 - C21
 - MW
 - MVAR
 - Frequency
 - PMU2
 - Status
 - V31
 - V32
 - C31
 - C32
 - Digital
 - Frequency

2. PMU Signal Management

PMU And Channel Characteristics

Signal Characteristics

4. PMU/Measurement Level Error Injection

Signal Name : V31

Signal Type : Phasor Voltage

Phasor Component: Positive Sequence

Phasor Flag: No Flag

Magnitude Value: 300000.0000

Angle Value (in Radians): 1.0000

Phasor Unit: 1

Phasor Offset: 0.00

☐ Add Magnitude Scale

Signal Magnitude Scale : 1

☐ Add Offset Scale

Signal Offset Scale (in Radians) : 0.0000

☐ Add Noise

Seed : 0

Distribution From : 0.0000

Distribution To: 1.0000

Communication Options

Communication Type : Spontaneous (Unicast)

Destination IP : 127.0.0.1

Multicast IP : 224.9.9.2

Remote Port: 4712

Local Port (Optional) : 4712

3. Communication Management

Protocol

5. Protocol Management Configuration

Data Format : C37.118

Samples Sent: 0

Show Packet : Limited Len 0 Bytes

6. Protocol Level Error Injection

☐ Header Error ☐ Frame Size Error ☐ Stutter Samples

☐ CRC Error ☐ Out of Order Samples

Time Offset: 0 seconds

Drop 0 Samples

Config Frame Errors

Offset(h) 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

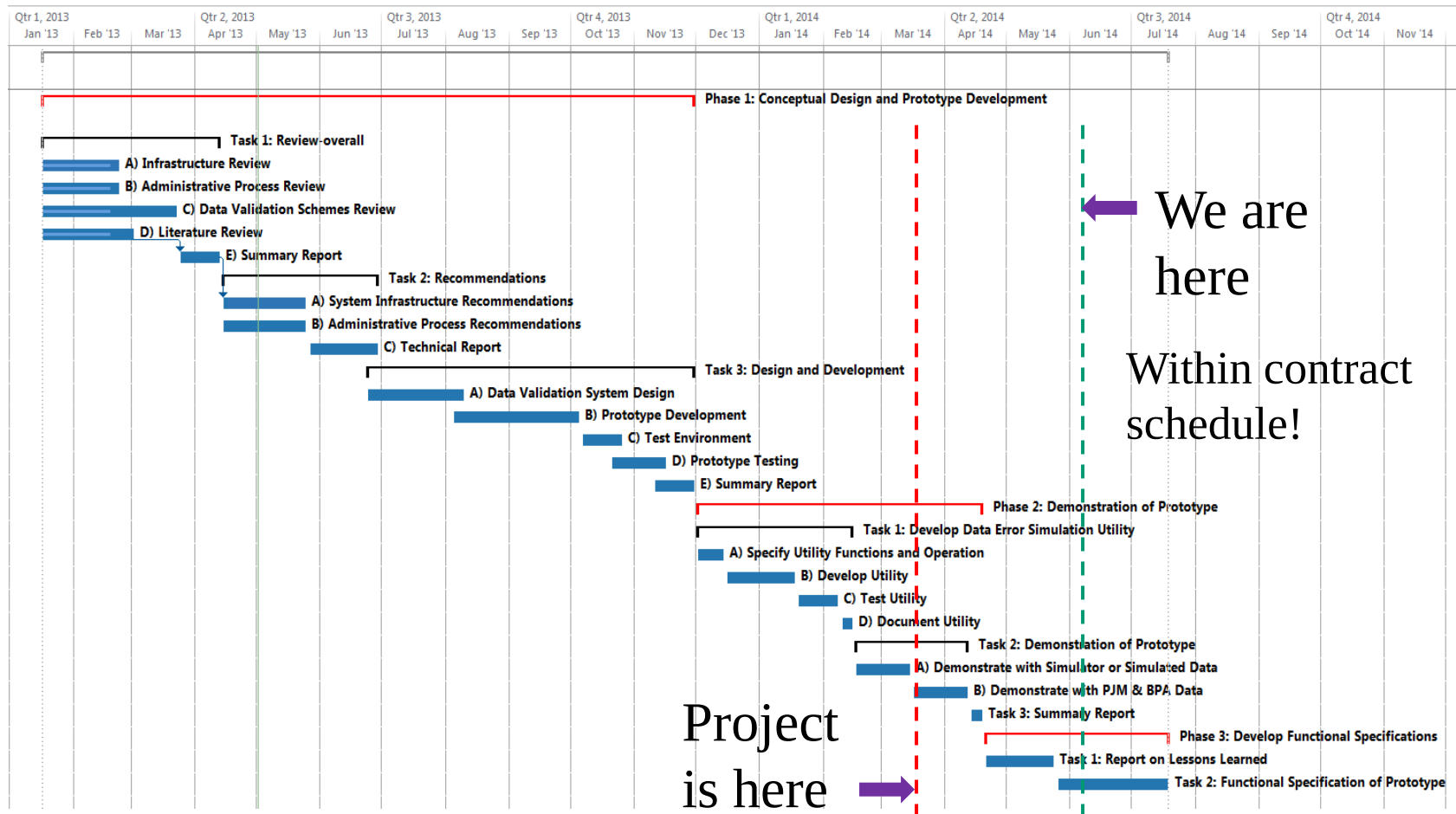
7. Start/Pause/Stop Simulation

Start Pause Stop

Wed Apr 09 14:34:16 2014> Configuration updated.



Overall Project Schedule



Risk Factors

- Delay in access to data for demonstrations
- Available data may not have all the problems for demonstration of full functionality



Status and Next Steps

- Phase 1 complete
 - Prototype developed and tested
- Phase 2 ready for demonstration
 - Develop Error Simulation Utility (complete)
 - Demonstrated PDVC with simulated data (complete)
 - Demonstrate PDVC with real-time data
 - Working with BPA on on-site testing with real-time data
 - Plan to have demonstration with PJM also
- Phase 3 - Function Requirement Report to follow demonstrations



Questions?

