Consortium for Electric Reliability Technology Solutions

NERC Disturbance, Alarm, Response, and Analysis (DARA)

FUNCTIONAL SPECIFICATION

NERC DISTURBANCE, ALARM, RESPONSE AND ANALYSIS

By

CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS (CERTS) / ELECTRIC POWER GROUP (EPG)

For

NORTH AMERICAN ELECTRIC RELIABILITY COUNCIL (NERC)

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CERTS Consortium for Electric Reliability Technology Solutions

Electric Power Group

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EXECUTIVE SUMMARY

The objective of this document is to deliver an application with alarm and notification capability such that if designated values (threshold) such as median frequency deviation exceeds a enterable value the data on the displays and in the reporting table will be flagged in red, and a notice will be sent to a pre-established email list indicating the threshold that was exceeded, the threshold setting, the actual value of the parameter, and the date and time of violation.

All alarms and events will be saved for five years with its corresponding tags for alarming tracking and analysis purpose.

The major objectives are:

- Disturbance identification and data collection, Frequency Response calculation, alarms archiving (4 categories 16 types), frequency response, and Time Error Correction (TEC) archiving.
- Alarm record to include alarms status by: color-coded active, acknowledgment, manually replace statuses besides the alarm data
- 1-panel and 4-panel multi-view geographic visualization of Frequency Response and other data parameters in the ACE-Frequency application 1-panel and 4-panel display
- Alarms creation, archiving and collection for the AIE, Inadvertent and CPS-BAAL functions
- Interactive data collection for: alarms, frequency response, TEC and other parameters
- Interactive saving of data in CSV data format

1 Introduction

1.1 Purpose and Organization of document

The purpose of this document is to define the functional specification for the Disturbance, Alarm, Response, and Archive (DARA). In addition, the document describes the DARA system processes required and the geo-graphic and multi-view visual components that will allow the users to effectively monitor and analyze performance and check for compliance with NERC Standards. This document describes the Functional Requirements, Alarm Types and Requirements, User Interface Requirements, Visualization Requirements, Data Flow, Database Structure and Hardware Data Communications and System Software Architecture of the application.

1.2 Background

The Consortium for Electric Reliability Technology Solutions (CERTS) has been formed to perform research, develop, and disseminate new methods, tools, and technologies to protect and enhance the reliability of the U.S. electric power system under the emerging competitive electricity market structure. The members of CERTS include former Edison Technology Solutions (ETS), Lawrence Berkeley National Laboratory (LBNL), Oak Ridge National Laboratory (ORNL), the Power Systems

Engineering Research Consortium (PSERC), Sandia National Laboratories (SNL) and Electric Power Group. Southern California Edison (SCE) acts as a CERTS Research Provider.

Industry restructuring and FERC's Order 2000 are leading to the formation of ISOs and RTOs. The current and developing ISOs and RTOs will manage wide-area transmission grids that are very dynamic and complex. NERC's Security Coordinators will also be challenged to coordinate and support the reliability activities across these wide-area grids. Unfortunately, the existing support systems and tools used to manage the transmission grid are based on the deterministic procedures of traditional energy management system (EMS) data and applications. CERTS, in an effort to address the limitations of the current support applications and tools, developed a vision for wide-area integrated, real time reliability, adequacy and performance monitoring tools. There is a special need for operational tools that enhances the Security Coordinators and dispatchers' ability to quickly assess the adequacy of supply and demand as well as monitor and track the control performance of a balancing authority, within a competitive electricity market. CERTS is funded by Department of Energy to develop reliability applications to support NERC's Security Coordinator functions.

The application to be developed for NERC is the Disturbance, Alarm, Response, and Analysis (DARA). Geo-graphic and Multi-view plots will be developed for Performance Monitoring.

The development and prototyping of the DARA System will help the Control Areas to monitor and resolve the issues related to the. The application will enhance the Regional Administrators' ability to perform compliance monitoring functions with current and future NERC reliability standards for each of the control areas under their jurisdiction. Also, the application will help the NERC Global Administrators to ensure that the supply meets with the demand and to add/remove control areas.

2 DARA Functional and Data Flow Overview

The main purpose for the DARA subsystem is to create an integrated process for NERC real time monitoring applications disturbances, alarms, frequency response, and post analysis. Figure 1 shows an overview for the integrated four functionalities and its-data flow. The figure also shows that the same DARA approach will be applied to the NERC ACE-Frequency, AIE, Inadvertent, and CPS-BAAL functions. The following sections will describe the functionality and data requirements for each of the 8 major functions of the integrated DARA system.

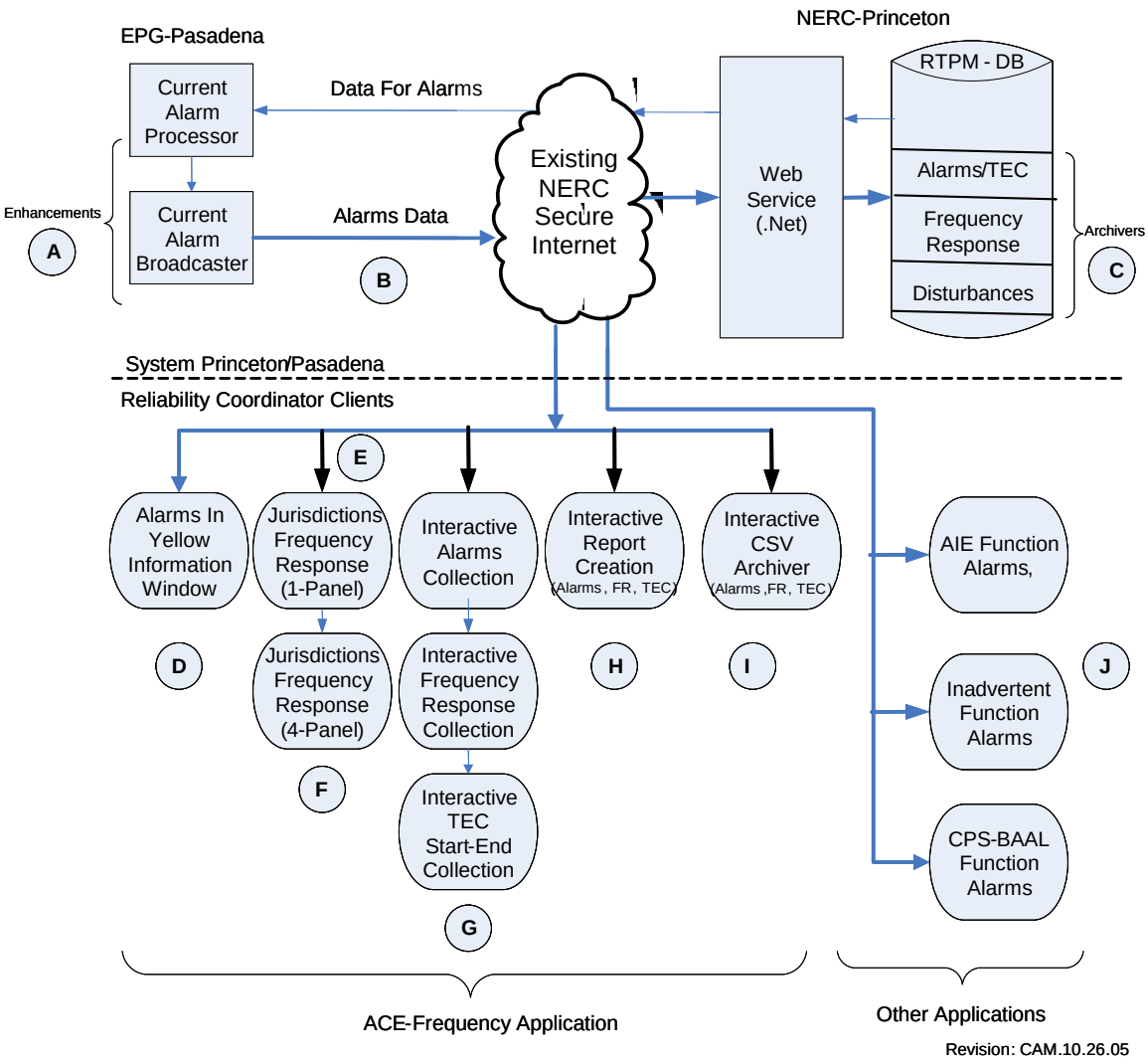


Figure 1 – Data Flow Overview

3 Enhancements for Alarm – Messaging Broadcasting - Function A

For the past three years, the Automatic Frequency Notification system has been running continuously as a stand alone program on the EPG Server in Pasadena. It is designed to monitor the NERC RTPM Database and send email messages to a select number of recipients when certain conditions have been met. Though this application has undergone some minor changes over the years, the architecture has not changed. This application relies on two basic exterior components in order to operate correctly:

1. Internet access to NERC.
2. Access to an SMTP server to send the emails out.

If either of these components is not available, the AFN will not function correctly. The AFN will send a message if Internet access to NERC is lost, but it is not equipped to determine whether or not the SMTP server is available.

4 Alarm Creation, Broadcasting and Archival – Function B

This activity involves the Alarm Processor, the Alarm Broadcaster and the web service. The Alarm Processor will monitor the acquired data for alarm conditions and notify the alarm broadcaster when an alarm condition is met. The triggers for the alarms will be defined in a configuration file. Following are the requirements for this function.

- Broadcast of alarms from current alarm processor to the RTPM database. The Alarm Broadcaster will be responsible for sending the alarm data to the database.
- Archiving of 4 categories of 16 alarm types, described below, with alarm types, priority, color-coded for active acknowledgments, manual replacement condition.
- Calculation and archiving online for up to 90-days of Frequency Response
- Archiving of Time Error Correction (TEC) alarms.
- The application must provide a user interface for selecting disturbance trigger conditions the application should watch for. The user will be able to select from the following types of triggers:
  - Any of the 16 alarms from the four categories in the alarm processor
  - A list of pre-defined events, loaded from the configuration file.

- The user may "force" the recording of a disturbance if the automatic process fails for some reason. This will involve indicating the type of disturbance that occurred, the time stamp, and the variables to save data for.
- The application must provide a user interface for configuring the parameters for each trigger condition, including the variable that will be monitored and checked against the trigger condition.
- The application must allow the user to save the current trigger configuration to a local file.

Following is the description of the current Alarm Processor and Alarm Categories and types currently broadcasted.

4.1 Wide-Area ACE/Frequency Alarms Requirements

Abnormal Frequency Notification (AFN)

The Real Time Interconnections Abnormal Frequency Notification (AFN) is a real time monitoring tool, part of the NERC/CERTS Frequency-ACE Monitoring System. The AFN is designed for real-time monitoring of abnormal interconnection frequencies, and to automatically issue emails to different stakeholders when certain performance criteria are met. The input data is provided by Control Areas to NERC over a secure connection using NERCnet, XML, and SOAP technologies.

Types of Alarms and Email Notifications

Figure 2 is a summary of the seven types of email messages generated by the AFN as well as the default parameters used as triggers to issue the Email Notifications.

Frequency Deviation Alarms

Email Type	Time Window	Threshold	Caps
Frequency Short Term Deviation	1 Min	0.028Hz	0.01
			-0.01
Frequency Prolonged Deviation	20 Min	0.030Hz	0.01
			-0.02
Frequency Long Term Deviation	60 Min	0.016Hz	Rolling Average

Data Quality Alarms

Email Type	Criteria 1	Criteria 2
Frequency Quality Data Problem	Messages not sent until measurement has been down for at least 15 minutes	Message is not resent for same conditions for 1440 minutes
ACE Quality Data Problem	Messages not sent until measurement has been down for at least 30 minutes	Message is not resent for same conditions for 1440 minutes

Server Availability Alarms

Email Type	Criteria 1	Criteria 2
NERC Data Servers Down	Messages not sent until servers are unavailable down for at least 15 minutes	Messages not sent until server is unavailable down for at least 120 minutes

Time Error Correction Alarms

Email Type	Criteria
TEC Started	Messages sent when a TEC ACTIVE alert is received
TEC Ended	Messages sent when a TEC ENDING alert is received

Figure 2 – Email Messages Summary and Criteria

Following is a description of each alarm.

Frequency Short Term Deviation
For each interconnection, the AFN checks to see if in the last minute the frequency changed by more than 28 millihertz (Note: This number is configurable). Caps are placed at 60.01Hz and 59.99Hz to prevent the AFN from generating a message under normal frequency conditions. If the frequency changed by more than 28 millihertz in the last minute and the current frequency has a value outside the Cap Area (greater than 60.01Hz or less than 59.99Hz), then the AFN records the frequency prior to the 28 millihertz change as a reference and issues an email (See Figure 2).

An example of the email is shown here:

Subject: SHORT TERM FREQUENCY DEVIATION QUEBEC, 0.028

SHORT-TERM: QUEBEC 8/12/2002 11:25:17 AM(EST) - Frequency Absolute value of two most recent 1 Minutes: ABS (60.020-59.991=0.029Hz>=0.028Hz.

Frequency Prolonged Deviation

Once an interconnection has had an occurrence of a Short Term Deviation, the AFN continues to monitor the frequency to see if it comes back to the previous value stored as a reference. If within 20 minutes (again, this number is configurable) the frequency does not return, emails are issued indicating that the interconnection still is under an abnormal frequency excursion.

An example of the email is shown here:

Subject: PROLONGED FREQUENCY DEVIATION QUEBEC

PROLONGED: QUEBEC 8/12/2002 11:36:49 AM(EST) – More than 20 minutes under Short-Term Deviation.

Frequency Long Term Deviation

The Abnormal Frequency Notification also tracks the average one-hour of frequency deviation from 60 Hertz. If the average deviation is greater than the threshold shown in table 2.1, (configurable in the system) emails are sent.

An example of the email is shown here:

Subject: LONG TERM FREQUENCY DEVIATION QUEBEC

LONG-TERM: QUEBEC 8/12/2002 9:32:40 AM(EST) - Rolling Hourly Frequency Average for last 61 minutes was 0.033Hz >= 0.030Hz.

Frequency Quality Data Problem

NERC has identified certain Control Areas as primary and secondary providers of frequency. These Control Areas are to send the frequency data every minute. In the event that the frequency is not sent for a configurable number of minutes, the AFN will issue an email.

An example of the email is shown here:

Subject: FREQUENCY QUALITY DATA PROBLEM WEST

FREQUENCY-QUALITY: WEST 7/16/2002 6:46:33 PM (PST) "Bonneville Power Administration Transmission" - Frequency source data has not been transferred for more than 15 Minut

ACE Quality Data Problem

In addition to checking for frequency, the AFN also checks for the availability of ACE data from Control Areas. If the data has not been sent to NERC for a configurable number of minutes, then AFN will issue emails accordingly.

An example of the email is shown here:

Subject: ACE QUALITY DATA PROBLEM WEST

ACE-QUALITY: WEST 7/17/2002 3:35:37 AM (PST) "Nevada Power Company" - ACE has not been transferred for more than 30 minutes

NERC Data Servers Down

In the event that the NERC Data Servers are unavailable for a configurable number of minutes, the AFN will send notification emails.

Subject NERC DATA SERVERS DOWN

NERC DATA SERVERS DOWN: 7/24/2002 7:37:25 AM (PST) - NERC Data servers have been unavailable for the last 30 minutes. NERC Data servers have been unavailable 67% of the time today.

TEC Started

When a Time Error Correction (TEC) START notification is issued by one of the Reliability Coordinator Desks, the AFN issues email announcing the date and time that the TEC is expected to start as well as the new target frequency the system is expected to stabilize. During a TEC, the Frequency Deviation Alarms Cap Area (see Figure 2.1) moves accordingly around the TEC target frequency.

Example of a Start Time Error Correction Email

Subject: TEC EAST STARTED, 59.98

TEC ACTIVE, START=8/10/2002 4:02:42 PM (EST), Sched Freq=59.98

TEC Ended

When a Time Error Correction (TEC) END notification is issued by one of the Reliability Coordinator Desks, the AFN issues email announcing the date and time that the TEC is ending. After a TEC ENDING email, the Frequency Deviation Alarms Cap Area (see Figure 2.1) returns to the normal bandwidth around the normal operating frequency (60.00Hz).

Example of a Stop Time Error Correction Email

Subject: TEC EAST ENDED

TEC, START=8/10/2002 12:03:37 PM (EST), End=8/11/2002 11:52:36 AM (EST)

CPS1 1-Minute Alarms
Create alarm for 1-Minute CPS1 exceeding 100%. Make the 100% user enterable.
Create alarm for 1-Minute CPS1 exceeding +/- 572%, BAAL violation. Make the 572% user enterable.

Frequency Value Alarms
Create High level alarms each time the current interconnections frequencies exceed, 60.5 (anytime), 60.2 (anytime), 60.05 (for more than 10-minutes), 60.05 (for more than 5-minutes), 59.95 (for more than 5-minutes), 59.95 (for more than 10-minutes), 59.91(anytime), 59.82 (anytime).

Email Address List Structure
The Abnormal Frequency Notification is designed such that a different list of email addresses may exists per Interconnection per Email Type. For example, with the Eastern Interconnection, there could be five different email address lists, one per Email Notification Type.

5 Archivers - Function C

The following parameters will be collected and archived:

5.1 Alarms

- Frequency Deviation Alarms
- Data Quality Alarms
- Server Availability Alarms
- Time Error Correction Alarms

5.2 Time Error Correction

- Speed Time
- Slow Down Time

5.3 Frequency Response

- **Panel 1** shows the selected Jurisdiction color-coded, using the difference between jurisdiction Frequency Response and its frequency bias for the of the last frequency disturbance.
- **Panel 2** shows image plot of Frequency Response for selected Jurisdiction for the last 50 frequency disturbances;
- **Panel 3** shows bar/line (selectable) chart of Frequency Response of user selected jurisdiction from the image plot for the last 50 (enterable) frequency disturbances.
- **Panel 4** will display tabular data for the variables from each of panels 1, 2,

5.4 Disturbances

- Short Term
- Long Term

6 User Interface Feedback of Alarms - Function D

All key alarm parameters must be displayable in the yellow information window, with flashing red for active, not flashing green for acknowledgment and magenta for manually replacement.

7 Frequency Response - Functions E and F

This application will be designed to perform the following functions:

- Calculate interconnection frequency disturbance;
  - Set disturbance event flag using 1-minute frequency maximum and minimum to compare with the interconnection frequency threshold.
  - The indicator will be set to 1 when the difference between maximum and minimum of sub-minute interconnection frequencies exceeding ±35MHz, otherwise, the indicator will be set to 0.
- Calculate Balancing Authority Frequency Response for the disturbance using the 1-minute ACE and frequency immediately before the step change in the frequency and after the step change in the frequency.
- Jurisdiction Frequency Response tracking for user selected Jurisdiction with the image plot for the last 50 frequency disturbances;
- BA Frequency Response tracking for user selected Balancing Authority with bar/line plot for the last 50 frequency disturbances.

Example:
At 9/9/2005 7:39 AM, the difference between maximum and minimum interconnection frequencies at this minute is greater than 35 MHz.
Control Area Bias=-60 MW/0.1Hz
Pre disturbance: 9/9/2005 7:38AM ACE=20 MW, frequency=60.01Hz
Post disturbance: 9/9/2005 7:40AM ACE=10 MW, frequency=59.985Hz
Frequency Response=-60+ (10/0.25)=-20MW/0.1Hz

Frequency Response Calculation

The calculation for each Balancing Authority Frequency Response uses the 1-minute ACE and frequency immediately before the step change in the frequency and after the step change in the frequency. The formula for Frequency Response is:

Frequency Response=Bias+ (delta ACE/10*delta F)

Frequency Response Visualization

The Disturbance-Event Visualization will allow end users to monitor via the 1-panel and the 4-panel visuals specific parameters such as jurisdiction Frequency Response for those instances when a disturbance-event has been identified. Figure 3 is a sample of the multi-view visualization requirements.

The main panel user interface will have a tab in the upper right hand corner that will present the Disturbance View user interface.

The default view will be a 1-panel display, showing the jurisdictions colored by the frequency response value. The data will be updated automatically, as in the other 1-panel displays in the ACE application. The user will select one or more jurisdictions to focus on, and drill down to the 4-panel display, shown below.

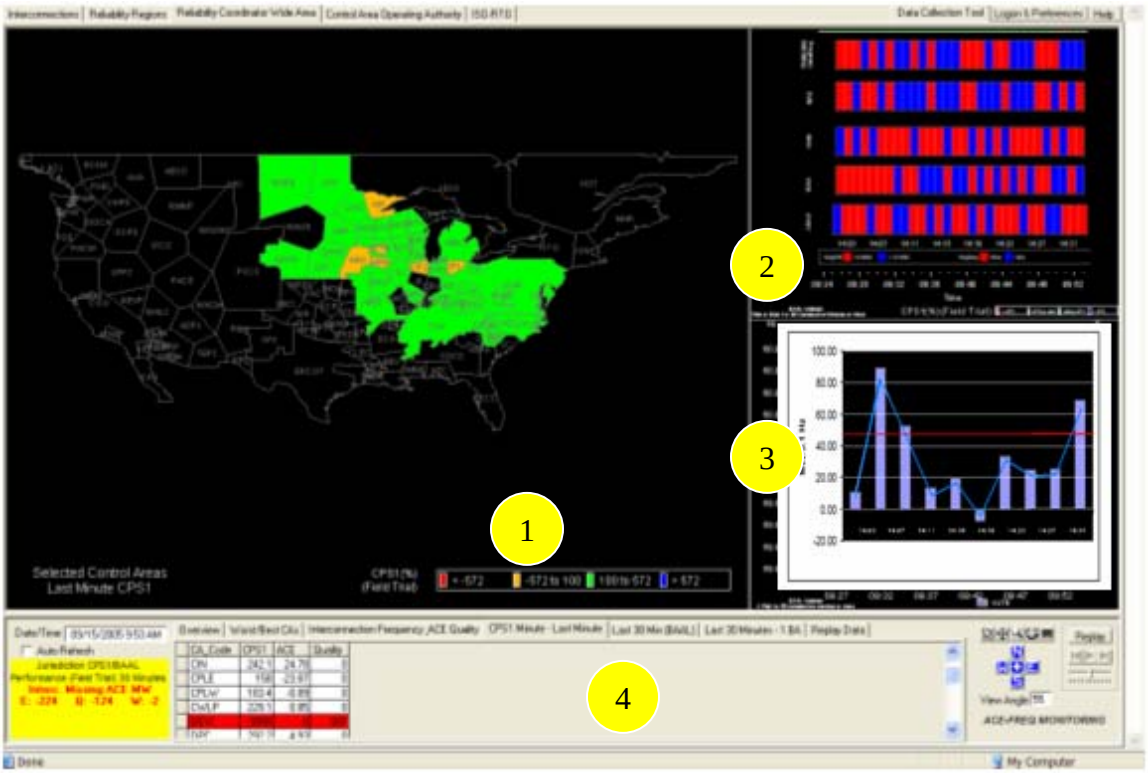


Figure 3– Jurisdictions Frequency Response Visualization for Disturbances

There will be a one 1-panel and one 4-panel display for each disturbance type, including the Frequency response. The Frequency Response 4-panel display content for any jurisdiction most likely will be:

- **Panel 1** shows the selected Jurisdiction color-coded, using the difference between jurisdiction Frequency Response and its frequency bias for the of the last frequency disturbance.
- **Panel 2** shows image plot of Frequency Response for selected Jurisdiction for the last 50 frequency disturbances;
- **Panel 3** shows bar/line (selectable) chart of Frequency Response of user selected jurisdiction from the image plot for the last 50 (enterable) frequency disturbances.
- **Panel 4** will display tabular data for the variables from each of panels 1, 2, 3.

Figure 4 and Figure 5 show the detail of Frequency Response Tracking visualization.

- The disturbance 1-panel and 4-panelviews will share the same guidelines and principles with the other 4 panel views in the ACE.
- The disturbance views must show the data for the most recent disturbance, as determined by a query to the database.
- The database must support requests for disturbance data.
- The Disturbance View will be configurable in the same manner as the other views in the ACE application.

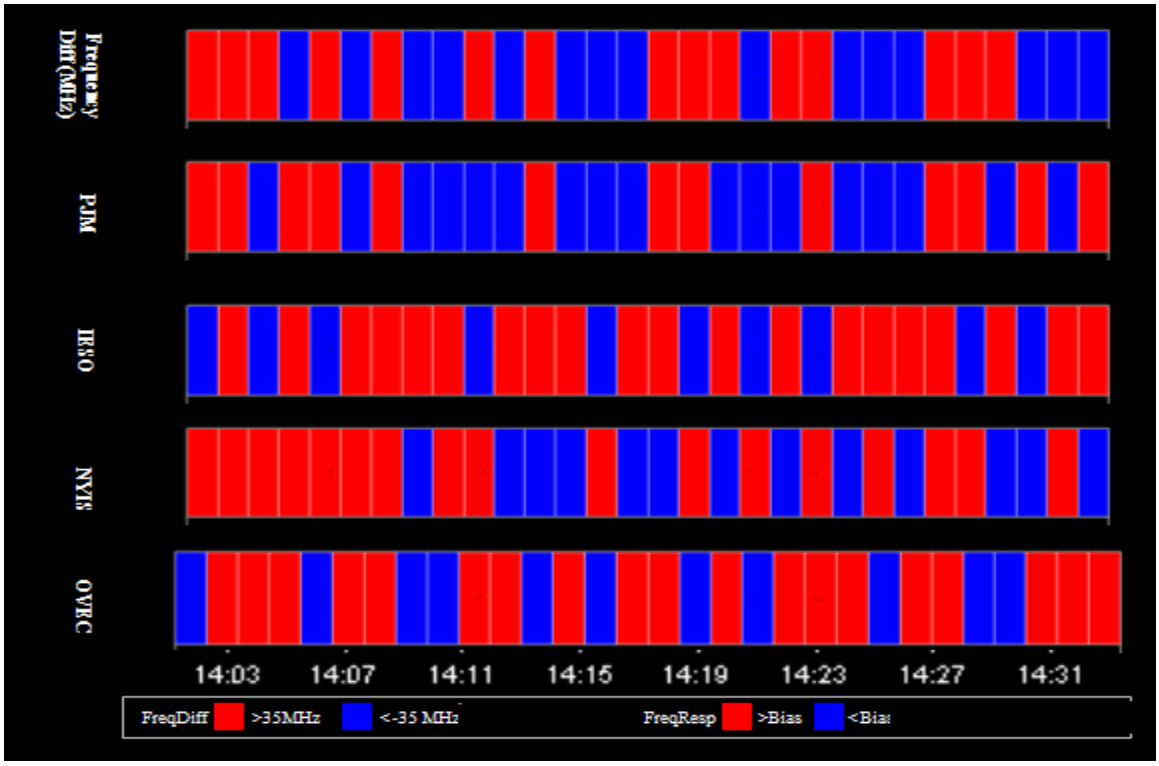


Figure 4 – Tracking Frequency Response Image Overview for Selected Jurisdiction

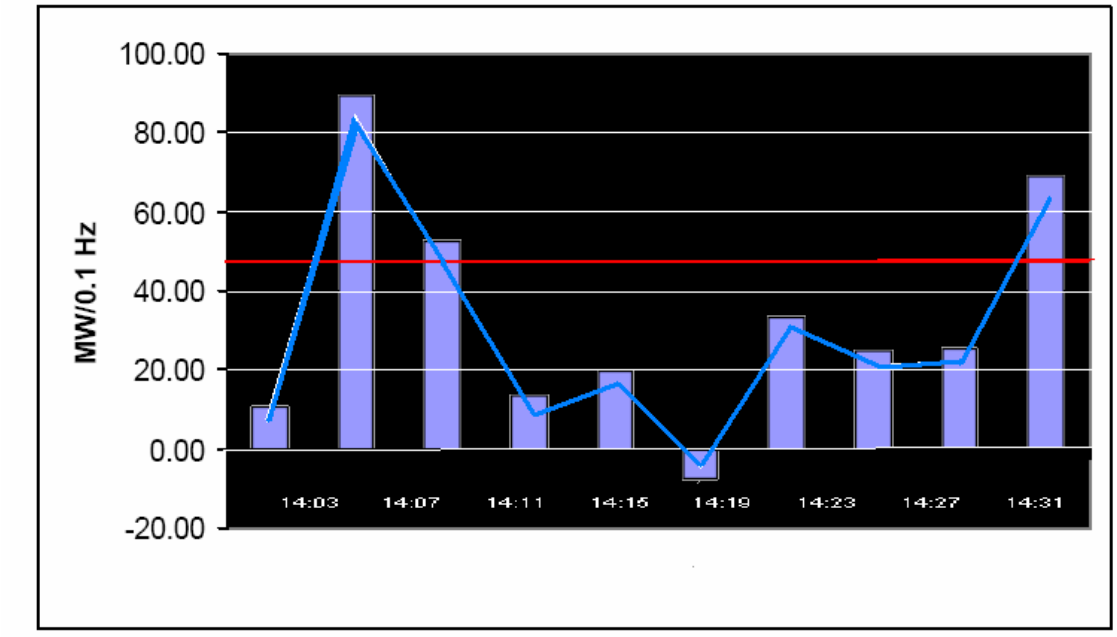


Figure 5 – Tracking Frequency Response for Jurisdiction Selected in Image

8 Interactive Data Collection - Function G

The system needs to automatically capture alarms, disturbances and events when they occur. The type of alarms and disturbance, date-time of the disturbance, and other descriptive parameters will be stored on the central server. The user will be able to retrieve data for the alarms, disturbances and events via the web service, plot the retrieved data, generate reports, and save the data to files.

General requirements

- The DCT user interface will have a new tab in the upper right hand corner tab for selecting the "Alarm, Disturbance and Event Collector" functionality. This will present the alarm, disturbance display and interactive disturbance data collection user interfaces described below.

9 Interactive Alarm and Disturbance Data Collection User Interface

- The application must present the user with a list of alarms and disturbances that may be viewed for a given time period.
- The application will provide a user interface for selecting the variables to collect that is similar to the one used by the DCT, Figure 6.

Figure 6 - Disturbance-Event data will be collected via the Data collection display

For a selected disturbance, the application must allow the user to select the time range centered on the disturbance time to retrieve data for. The current display for selection, Figure 7, will be adapted to include Alarms, Disturbances and Events

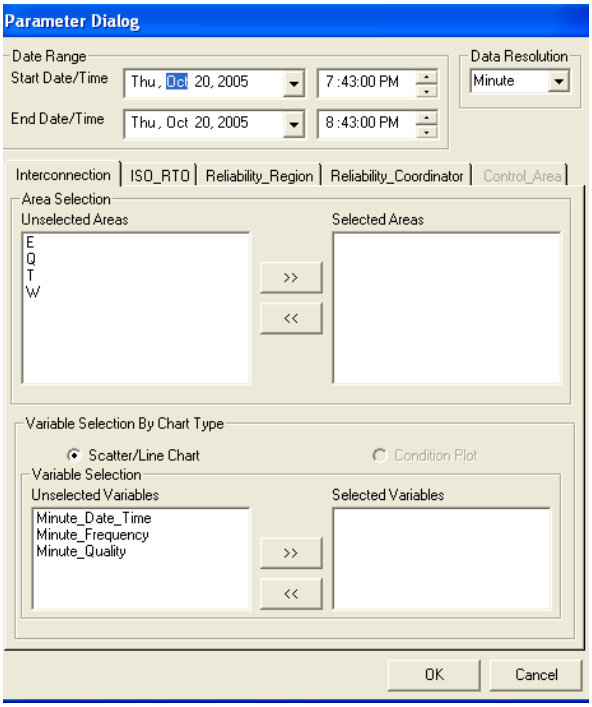
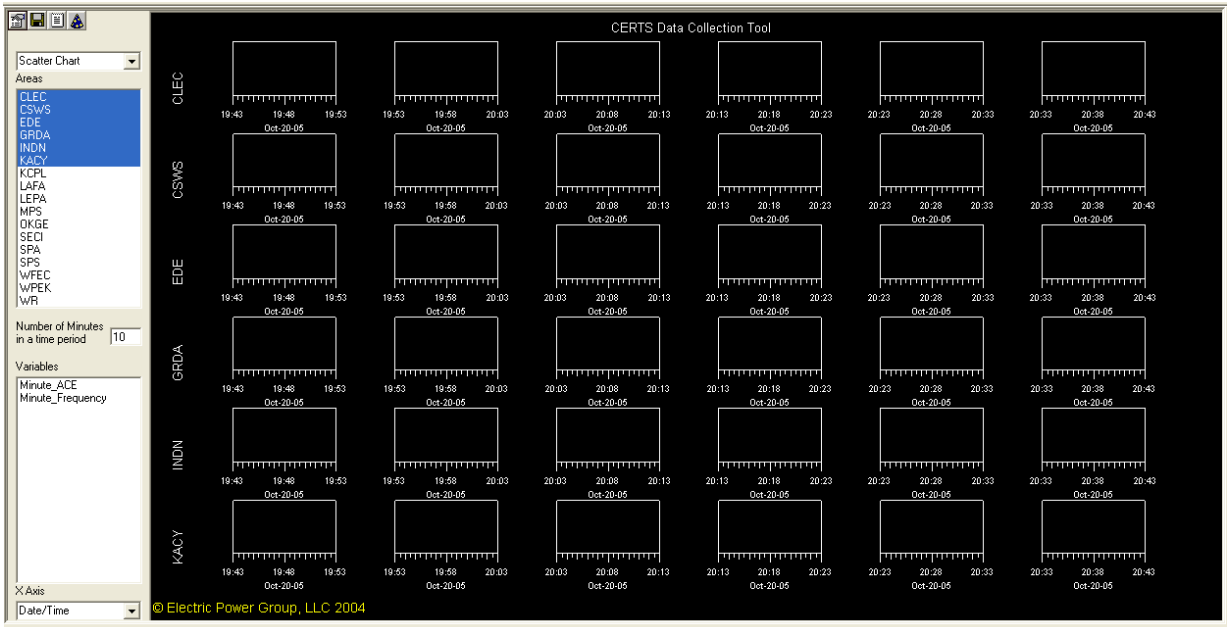


Figure 7 – Parameter Dialog Window

Disturbance-Event data calling parameter will be entered using a user interface similar to this one, but with options for selecting the alarm, event or disturbance to view.

- The system must have the capability to view data plots for a particular disturbance. The plots must be similar to the current version 3.0 DCT display, Figure 8.



Date/Time	Area	Minute_ACE	Minute_Frequency
10/20/2005 19:43	CLEC	-6.996	59.998
10/20/2005 19:44	CLEC	-0.505	59.999
10/20/2005 19:45	CLEC	3.73	60
10/20/2005 19:46	CLEC	0.85	59.999
10/20/2005 19:47	CLEC	-8.327	59.991
10/20/2005 19:48	CLEC	-9.083	59.998
10/20/2005 19:49	CLEC	-6.905	60.002
10/20/2005 19:50	CLEC	-0.632	60.009
10/20/2005 19:51	CLEC	-0.952	60.012
10/20/2005 19:52	CLEC	-0.614	60.01
10/20/2005 19:53	CLEC	0.412	60.003

Figure 8 - Disturbance-Event will be plotted using with this interface

10 Interactive Data Report Creation - Function H

- All alarms
- Frequency Response
- Time error Correction

Alarms, Disturbance-Event will be reported using and equivalent display to the one shown in Figure 8 and the wizard to use will be equivalent to Figure 9.

- The application must have reporting capabilities similar to the current DCT reporting capabilities

Alarms, Disturbance-Event will be reported using a user interface similar to Figure 10 and the wizard to use will be similar to Figure 10.

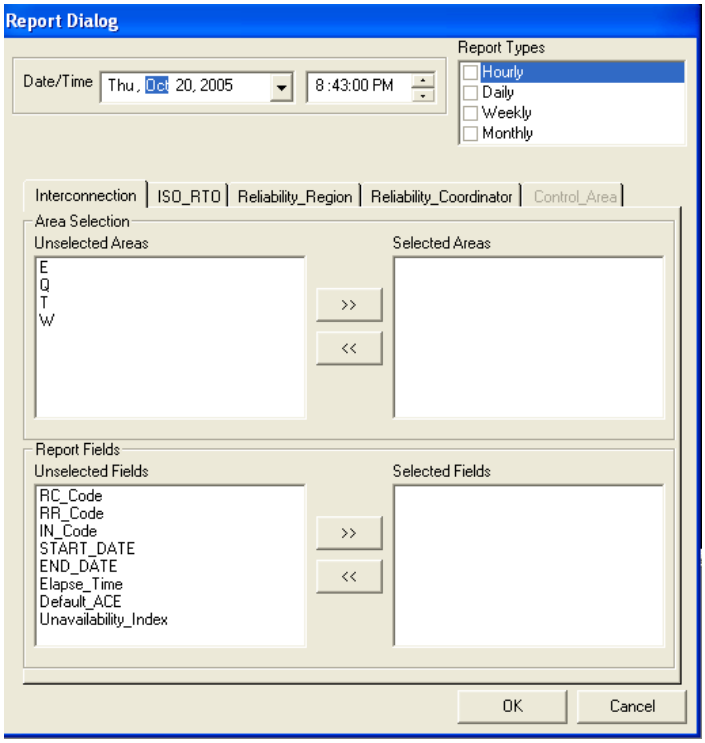


Figure 9 – Report Dialog

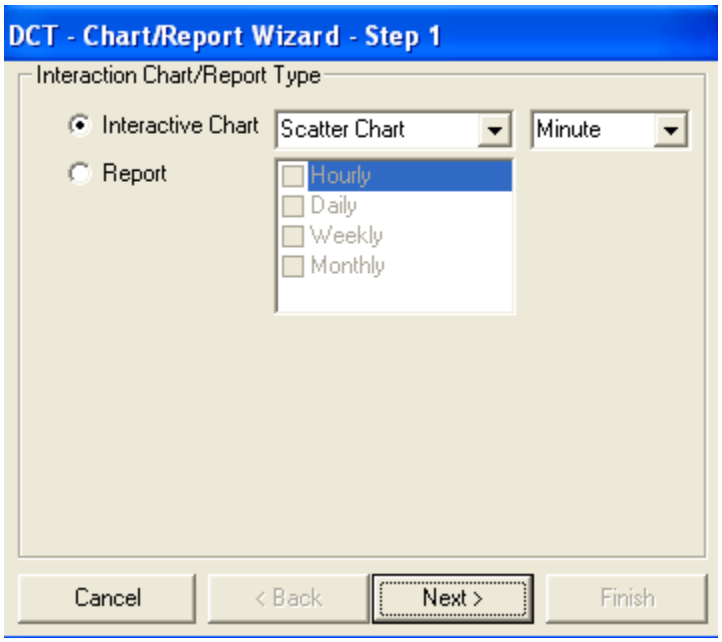


Figure 10 – DCT – Chart/Report Wizard – Step 1

- The application must have the ability to print the contents of the event display.

11 CSV Output of Disturbance Data - Function I

Similar to the equivalent report and archiving sections of the ACE-Frequency

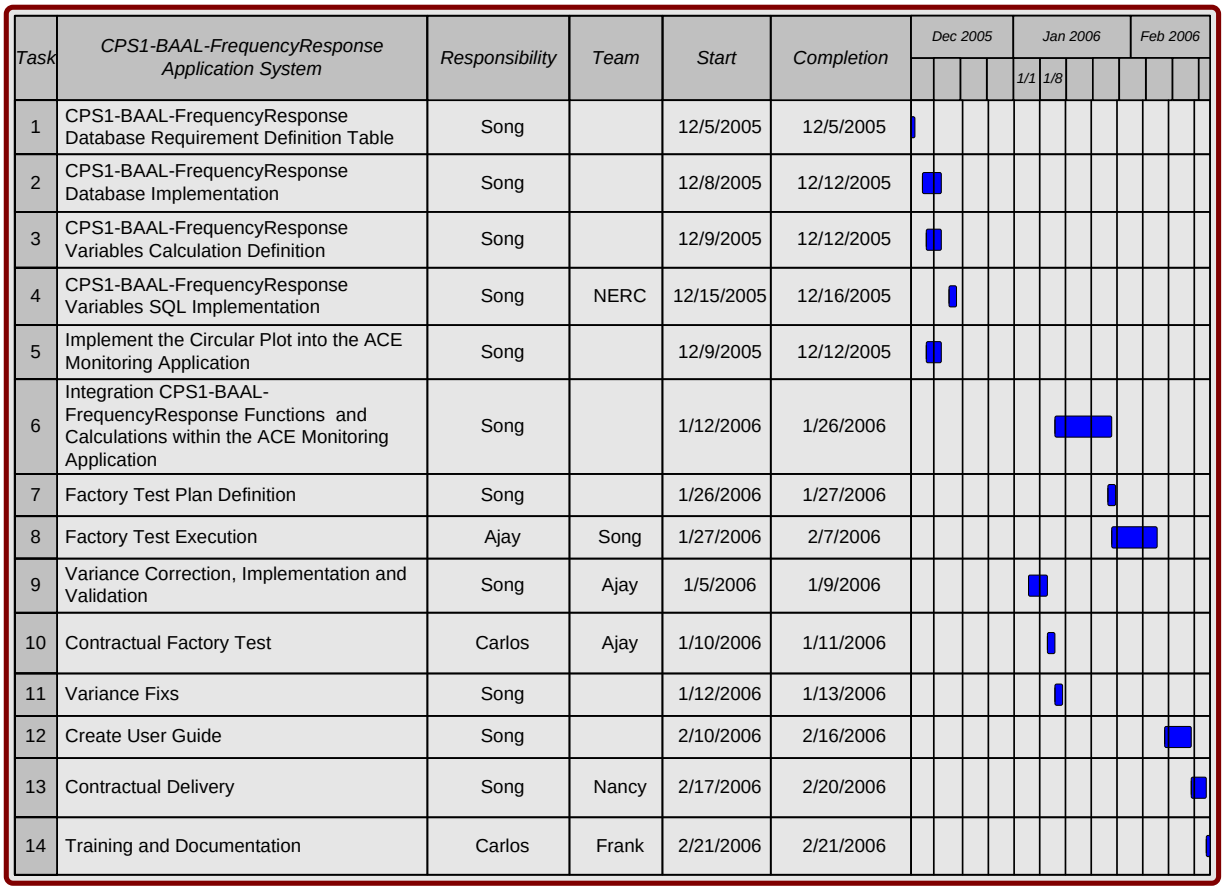
- The system must have the ability to save the system data for the displayed alarm, disturbance and events as CSV files on the local machine

12 AIE, Inadvertent, CPS/BAAL Reporting - Function J

- The same process used to identify, capture, display and report alarms, disturbances and events for the ACE will be used for the other applications (AIE, Inadvertent, CPS/BAAL).

13 Major DARA Project Task and Schedule

Task	CPS1-BAAL-FrequencyResponse Application System	Responsibility	Team	Start	Completion
1	CPS1-BAAL-FrequencyResponse Database Requirement Definition Table	Song		12/5/2005	12/5/2005
2	CPS1-BAAL-FrequencyResponse Database Implementation	Song		12/8/2005	12/12/2005
3	CPS1-BAAL-FrequencyResponse Variables Calculation Definition	Song		12/9/2005	12/12/2005
4	CPS1-BAAL-FrequencyResponse Variables SQL Implementation	Song	NERC	12/15/2005	12/16/2005
5	Implement the Circular Plot into the ACE Monitoring Application	Song		12/9/2005	12/12/2005
6	Integration CPS1-BAAL-FrequencyResponse Functions and Calculations within the ACE Monitoring Application	Song		1/12/2006	1/26/2006
7	Factory Test Plan Definition	Song		1/26/2006	1/27/2006
8	Factory Test Execution	Ajay	Song	1/27/2006	2/7/2006
9	Variance Correction, Implementation and Validation	Song	Ajay	1/5/2006	1/9/2006
10	Contractual Factory Test	Carlos	Ajay	1/10/2006	1/11/2006
11	Variance Fixs	Song		1/12/2006	1/13/2006
12	Create User Guide	Song		2/10/2006	2/16/2006
13	Contractual Delivery	Song	Nancy	2/17/2006	2/20/2006
14	Training and Documentation	Carlos	Frank	2/21/2006	2/21/2006



14 Training

CERTS will schedule and provide on-site training of NERC Training Personnel in the various display and Grid 3-P program interface methodologies.

15 Documentation

CERTS will provide a User Guide and a summary brochure describing the details of real-time CPS1, Frequency Response and BAAL performance monitoring and tracking.