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Using XFRACAS[™] as a PVROM Database Tool

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Prepared by
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Abstract

ReliaSoft's XFRACAS[™] is a tool chosen by Sandia National Laboratories (SNL) for the purpose of collecting and organizing photovoltaic (PV) system field data that is to be used in assessing PV system reliability. It is a Web-based, closed-loop, incident (failure) reporting, analysis, and corrective action system software package designed for the acquisition, management and analysis of quality and reliability data from multiple sources. The ability to export PV system times-to-failure and times-to-suspension for ready analysis by ReliaSoft's Weibull++[™] and RGA[™] was a primary consideration in choosing XFRACAS[™] as a reliability data collection tool.

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NOMENCLATURE

AC	alternating current
BOM	Bill of Materials
CSI	Customer Support Information
DC	direct current
GMT	Greenwich Mean Time
ID	identification
IIS	Internet Information Services
kWh	kilowatt-hour
OOS	out-of-service
PRR	Problem Resolution Report
PV	photovoltaic
PVROM	Photovoltaic Reliability Operations and Maintenance
SNL	Sandia National Laboratories
SON	Sandia Open Network
SRN	Sandia Restricted Network
UTC	Coordinated Universal Time

1. INTRODUCTION

ReliaSoft's XFRACASTM is a tool chosen by Sandia National Laboratories (SNL) for the purpose of collecting and organizing photovoltaic (PV) system field data that is to be used in assessing PV system reliability. It is a Web-based, closed-loop, incident (failure) reporting, analysis, and corrective action system software package designed for the acquisition, management and analysis of quality and reliability data from multiple sources. This tool enables:

- reporting of reliability-related issues for PV systems and components in the field,
- specifying the details of a failure analysis,
- tracking the failure analysis and managing actions associated with resolving identified field problems,
- reporting installation details when a PV system is installed/commissioned,
- viewing PV system configurations (Bills of Material),
- searching customer support, incident, problem resolution report, action, failure analysis, and system configuration records based on specified criteria, as well as generating reports and graphs, and
- exporting XFRACASTM data to other ReliaSoft reliability/availability analysis tools.

The ability to export PV system times-to-failure and times-to-suspension for ready analysis by ReliaSoft's Weibull++TM and RGATM was a primary consideration in choosing XFRACASTM as a reliability data collection tool (version 6.0.18 is addressed in this report).

The photovoltaic reliability operations and maintenance (PVROM) database (XFRACASTM database version 6.0.18.1) resides on a Sandia Restricted Network (SRN) server and is accessed through the Sandia Open Network (SON). Access restrictions (required login ID and password) ensure that only source users (PV industry partners) can access the database. The SNL password administration organization issues SON login IDs and passwords. XFRACASTM source permissions ensure that individual source users can access only their own data.

The XFRACASTM platform supports both real-time and legacy failure/suspension data acquisition. Real-time incident records are created and maintained with the aid of an Incident Wizard and an Incident Tracking Utility. Legacy data is imported into the database via a Microsoft Excel template (Excel version 97-2003 format). XFRACASTM supports incident record searches and report generation, and facilitates the export of data to ReliaSoft reliability life data analysis and reliability growth analysis software products. These reliability analysis tools allow the performance of PV system predictive analyses and sensitivity studies, and the optimization of operations and maintenance strategies.

This report provides a guide for the SNL instantiation of XFRACASTM, called PVROM, to be used by PV System owners who partner with SNL to track operations and maintenance activities on those systems. It also covers tasks for the SNL administrators super end users needed to ensure smooth operation by the PVROM users. This report will not cover all the features provided by the XFRACASTM platform, but only those pertinent to PVROM usage. Further XFRACASTM training can be obtained directly through Reliasoft (www.reliasoft.com).

2. GETTING STARTED

2.1. Initializing XFRACAS™ (SNL SUPERUSER task)

Prior to entering data into the XFRACAS™ database, there are some initialization tasks that must be performed as the software default parameters and settings need to be configured for PVROM needs. In particular, System Preferences (addressed in Section 14.5) must be reviewed and specified for the PVROM application. Data fields and field names as displayed in the Incident Tracking Utility record must be established and addressed accordingly. Some field names can be edited using the Resource Editor (Section 10.2), while others can be edited using the Manage Detail Fields Utility (Section 14.4). The default Lookup List options (Section 14.6) also need to be revised as necessary.

2.2. Accessing XFRACAS™ Homepage

The XFRACAS™ production application homepage is accessed by means of the following link: <https://xfracas.sandia.gov>. The source user is required to enter his/her login ID and password before the homepage will open.

The link for accessing the development application homepage (SNL user access only) is <http://xfracas-d.sandia.gov>. No login ID or password is required. SNL users will also need to install the XFRACAS™ Administrative Utility (see Section 10) in order to import Bills of Materials and historical PV system performance data. The XFRACAS™ Administrative Utility can only be executed on the Sandia Restricted Network.

2.3. Understanding Export Data Failure/Suspension Classification

The primary purpose of the PVROM database is to collect and organize PV system performance data so it can be used in Weibull++™ and RGA™ analyses. However, to obtain the correct data export files for both Weibull++™ and RGA™ it is first necessary to define appropriate menu options in the Incident Category and Failure Type lookup lists. These lookup lists are classified as either chargeable or non-chargeable such that PV system component failures (chargeable) and suspensions (non-chargeable) are determined in accordance with the following matrix:

Failure Type	Incident Category	Failure/Suspension Classification
Chargeable	Chargeable	Chargeable (failure)
Chargeable	Non-chargeable	Non-chargeable (suspension)
Non-chargeable	Chargeable	Non-chargeable (suspension)
Non-chargeable	Non-chargeable	Non-chargeable (suspension)

Thus, the sole basis for the menu option definitions and their classification as either chargeable or non-chargeable (see Appendix) is that the correct export data is obtained.

To access Incident Category or Failure Type lookup lists (**SUPERUSER only**):

1. From Home Page, click on Home tab
2. Click on Admin Home
3. Click on List tab
4. Click on General Lookup Lists
5. Scroll down to Incident Category Chargeable, Incident Category Non-chargeable, Failure Type Chargeable, or Failure Type Non-chargeable
6. Click on title to open window
7. Click on green ADD button to add options, blue EDIT button to edit options, or red DEL button to delete options

Note that the options in these lookup lists must be specified for each XFRACAS™ Entity (14.1) prior to beginning any of the tasks that follow and must not be changed once data has been entered into the database. Although new lookup list options may be added at any time, they will not apply to data already in the database.

2.4. PVROM Task Sequence

The order in which the PVROM tasks must be performed is important and is summarized as follows:

1. Create an appropriate Entity (Section 14.1) for each industry partner – **SNL SUPERUSER task**
2. Submit requests for Entity user login IDs and SON passwords to SNL Password Administration org. – **SNL task (See Note*)**
3. Create ADMIN user for each Entity (Section 14.3) – **SNL SUPERUSER task**
4. Create Entity USERS – **Entity ADMIN user task**
5. Create a non-serialized Bill of Materials (BOM) template for an Entity PV system (Section 3) – **Entity USER task**
6. Create serialized Bills of Materials based on the non-serialized template (Section 3) (Note that if Bills of Materials have been created using the XFRACAS™ BOM template [XFRACASImportTemplate_BOM.xls] they must be submitted to SNL for importing into the database) – **Entity USER task**
7. Import BOM templates into database – **SNL task**
8. Assign responsible individuals to the items in the non-serialized Bill of Materials (Section 4) – **Entity USER task**
9. Create a Customer Support Information record for each serialized Bill of Materials (Section 5) – **Entity USER task**
10. Generate incident records for all system-level and component-level events that result in a loss PV power generation (Section 6) – **Entity USER task**

*Note that all PVROM users needing a SON (Sandia Open Network) account must first contact the SNL Corporate Computing Help Desk at 505-845-2243. If PVROM users are not SNL employees then they must also initiate an Enterprise Person Application with the assistance of a sponsoring SNL organization.

3. BILL OF MATERIALS (BOM)

Before field incident data can be entered into the XFRACAS™ database it is necessary to construct an appropriate PV installation Bill of Materials. The first step in creating an XFRACAS™ BOM for a PV installation is to obtain or create a detailed configuration of the installation. Figure 1 is an example of an electrical one-line diagram that is suitable for use in creating a system BOM. A PV installation will typically consist of power transformers, AC and DC disconnect switches, inverters, DC optimizers, PV modules, data acquisition systems and various AC and DC system connections (e.g., cables, fuses, diodes, etc.). PV installation components can generally be grouped into one or more power blocks, where a power block consists of the collection of components associated with, for example, an inverter. It is recommended that a BOM be created for each unique system power block.

BOMs can be created using the XFRACAS™ Parts Import Template (Figure 2), which is a Microsoft Excel file (XFRACASImportTemplate_Parts.xls) located in the AdminApp folder (see Section 10). Caution: if using a Microsoft Excel spreadsheet other than the Parts Import Template, the spreadsheet must exactly mimic the Parts Import Template, including text formatting of all data columns. The Microsoft Excel Format must be 97-2003 (compatibility mode). Since copy/paste operations may change entry formatting, insertion of an apostrophe (') at the beginning of an entry may be necessary to ensure consistent text formatting for certain entry types (e.g., number, date, time, etc.). Figure 3 illustrates the construction of a PV power block BOM using this template. The top level (Level 1) of each BOM template is the power block designation. The major components of each power block (i.e., power transformers, AC/DC disconnect switches, inverters, PV modules, trackers, tracker controllers, etc.) are all Level 2 entries in the template. Note that similar parts in a BOM (e.g., all modules) are all given the same part “numbers” (see Part Number column in Figure 3) and the various electrical system connections (i.e., cables, fuses, etc.) are entered into the template as a single entry (e.g., ECON in Figure 3).

To ensure that exported data for BOM parts contain the necessary and sufficient data for analysis, it is strongly recommended that the following standardized part “numbers” be used in preparing all PV system BOMs.

TXL – high voltage transformer
TXS – low voltage transformer
UDS – utility disconnect switch

Level	Part Number	Part Description
1	SGSSS	SGS Solar System Power Block
2	TXL	480V/34.5kV Transformer
2	TXS	208V/480V Transformer
2	ADS	AC Disconnect Switch
2	DDS	DC Disconnect Switch
2	ECON	Array Electrical Connections
2	INV	Inverter
2	MOD	PV Module
2	LIGHT	Lightning Event

Figure 3. Example PV System Bill of Materials Template

ADS – AC disconnect switch

DDS – DC disconnect switch

INV – inverter

MAT – matrix

PS – power supply

FAN – cooling fan

ECON – electrical system connections (i.e., cables, connectors, fuses, diodes, etc.)

MOD – PV module

PLC – programmable logic controller

VFD – variable frequency drive

SOL – solenoid

VALVE – valve stack

PUMP – hydraulic pump

MOTOR – electric motor

TANK – tank

CYL – hydraulic cylinder

HOSE – hoses and fittings

DAS – data acquisition system

Although there will rarely be a need to go to a third level (e.g., parts internal to the inverter), the complexity of the BOM template depends upon the desired detail to which system component/part reliability is to be ascertained. However, the parent-child relationship of BOM entries needs to be kept in mind (i.e., Level 3 parts are necessarily children of the associated

Level 2 parts). When a BOM part is replaced, XFRACAS™ assumes that all of the children associated with that part are replaced as well. This is most certainly the case if all of the children are sub-components of the part being replaced.

Note that the BOM in Figure 3 contains a “part” (LIGHT) titled lightning event. A single lightning event may affect multiple components in a PV system, resulting in component damage and/or interruption of equipment operation. The purpose of the LIGHT BOM entry is to allow consolidation of potentially multiple, common-event (lightning) incident records per affected inverter array into a single inverter array incident record. Such an incident record affords the ability to account for multiple hardware failures/suspensions within an affected inverter array due to a common lightning event as a single incident occurrence in the reliability/availability analysis.

Next a serialized BOM is created by applying serial numbers to all entries in the XFRACAS™ Parts Import Template. Each of the major system components in a power block is initially serialized. Figure 4 illustrates the display of a serialized BOM for the BOM shown in Figure 3 (serial numbers shown are merely placeholders). Commissioning dates must also be provided in the Build Date column for all BOM entries.

Level	Part Number	Part Description	Part Version	Serial Number
1	SGSSS	SGS Solar System Power Block		SGS-1
2	TXL	480V/34.5kV Transformer		SCL-2
2	TXS	208V/480V Transformer		TXS-1
2	ADS	AC Disconnect Switch		ADS-1
2	DDS	DC Disconnect Switch		DDS-1
2	ECON	Array Electrical Connections		ECON-1
2	INV	Inverter		INV-1
2	LIGHT	Lightning Event		L-1
2	MOD	PV Module		M-U1-1
2	MOD	PV Module		M-U1-2
2	MOD	PV Module		M-U1-3

Figure 4. Example PV System Serialized Bill of Materials

Therefore, each PV facility/installation will have one or more BOMs, depending on the complexity and configuration of the PV system (e.g., the number of power blocks). This facilitates the proper component associations when system incident records are created in XFRACAS™ without adding unnecessary complexity to the BOM (lower level component/part details should be provided in XFRACAS™ incident descriptions). Furthermore, this approach provides the necessary level of detail for performing system reliability/availability analyses. Once a serialized BOM is created it can then be imported into XFRACAS™ using the XFRACAS™ Administrative Utility (Section 10).

BOMs can also be created within XFRACAS™. To create a System Template (i.e., a non-serialized BOM as illustrated in Figure 3) for each PV installation do the following (**ADMIN user only**):

1. From Home Page (ensure appropriate Entity is selected from Current Entity drop-down menu), click on Home tab
2. Click on Admin Home
3. Click on System tab
4. Select System Configuration
5. Click on Create Top Level System
6. Right-click on Top Level System (level 1) entry
7. Click on Create Part (repeat steps 5 and 6 for all “parts” at the system level – i.e., level 2)
8. Right-click on any part which is to be a “parent” of lower level parts (i.e., “children”)
9. Click on Create Part (repeat steps 7 and 8 for all “parts” to be created at the component level – i.e., level 3; e.g., parts internal to an inverter enclosure)

Note: when the BOM illustrated in Figure 3 is imported into XFRACAS™ using the Administrative Utility it will appear as illustrated in Figure 5.

To create a Serialized System (i.e., serialized BOM) from each System Template, serializing only those items for which operating information is to be tracked by item serial number, do the following (**ADMIN user only**):

1. From Home Page (ensure appropriate Entity is selected from Current Entity drop-down menu), click on Home tab
2. Click on Admin Home
3. Click on System tab
4. Select System Configuration
5. Click on Create Serialized System
6. Select the appropriate System Template
7. Enter a serial number
8. Enter system build date information (i.e., date of system commissioning)
9. Click on Save
10. Click on OK
11. Right-click on Top Level System (level 1) entry
12. Click on Create Serialized Part
13. Select part to be serialized
14. Enter serial number
15. Click on Save

16. Click on OK
17. Repeat steps 4 through 10 for all parts to be serialized at level 2
18. Right-click on any level 2 part that has children (i.e., level 3 parts)
19. Click on Create Part

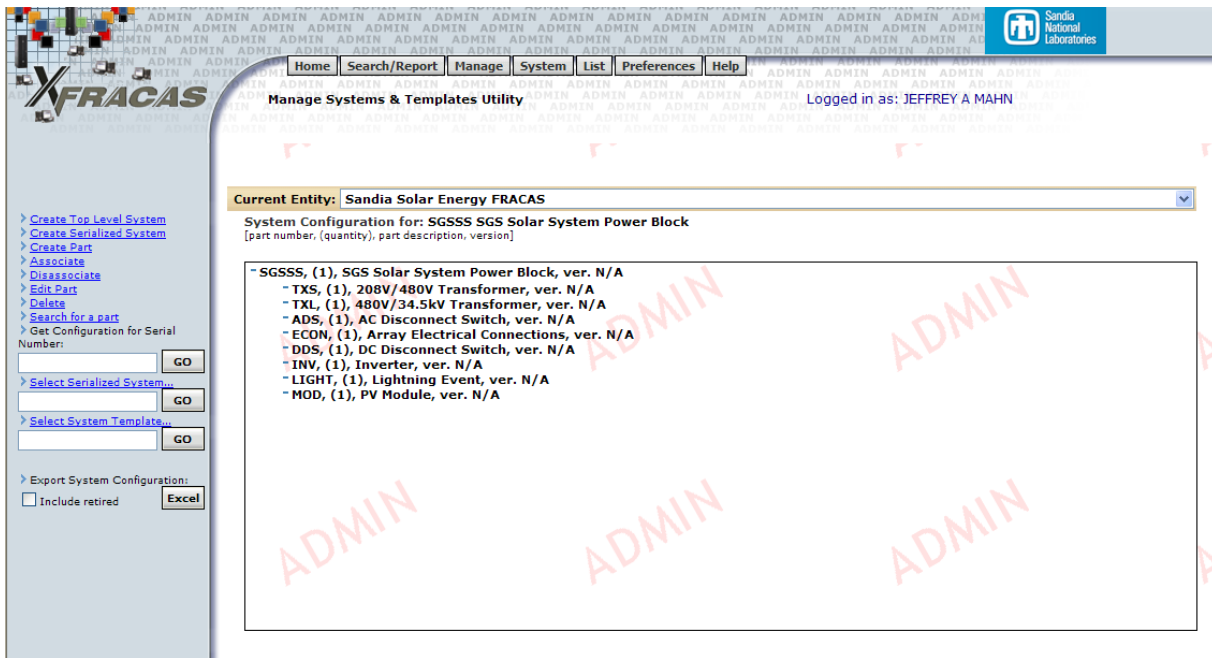


Figure 5. Bill of Materials Display in XFRACAS™

20. Enter a new part number (e.g., SSR for a solid state relay)
21. Enter a new part description (e.g., solid state relay)
22. Click on Save
23. Repeat steps 17 through 21 for all parts to be serialized at level 3

A serialized BOM can be easily replicated by exporting the initial serialized BOM to Microsoft Excel. Clicking on the Excel button on the left in Figure 5 will produce a BOM as illustrated in Figure 4. **Note: when an XFRACAS™ BOM is exported to Microsoft Excel it must be saved as a 97-2003 formatted (*.xls) Excel file (to preserve the text formatting) in order to be modified and imported back into XFRACAS.** Additional serialized BOMs can then be created from the replicated BOM.

Note: when historical incident data involving BOM parts replacements is to be imported into XFRACAS™ (Section 7.2), the appropriate replacement part serial numbers and replacement dates (Build Date) must first be entered into the applicable BOM.

4. RESPONSIBLE INDIVIDUALS

The administrative Manage Responsible Individuals utility associates users with the parts that they are responsible for and defines the e-mail notification list for incidents related to those parts. The associations made in this interface will determine who receives e-mail notifications from the system when an incident is created. If a part has a responsible individual assigned to it, the part will be displayed in the Responsible Part drop-down list in the Incident Tracking Utility (Section 6). Not every part in the BOM necessarily needs to have an assigned responsible individual. Assigning a responsible individual to the BOM Top Level System entry (aka parent) automatically assigns all BOM parts (aka children) to that individual. Since the Responsible Part field is required for creating an incident record, at least one responsible individual must be specified for the system. To assign responsible individuals, do the following (**ADMIN user only**):

1. From Home Page (ensure appropriate Entity is selected from Current Entity drop-down menu), click on Home tab
2. Click on Admin Home
3. Click on System tab
4. Select Responsible Individuals
5. Click on Select System Template
6. Select Desired System Template
7. Expand BOM
8. Right-click on desired BOM part
9. Click on Assign Individual
10. Click on Desired individual
11. Click on Save

5. CUSTOMER SUPPORT INFORMATION (CSI) RECORD

The Customer Support Information utility captures installation details when a system is installed/commissioned and manages information for particular serialized systems, including installation details, customer contact information, and incident report history. A CSI record must be created for each serialized BOM, specifically to record the commissioning date associated with the BOM. To create a CSI record, do the following:

1. From Home Page (ensure appropriate Entity is selected from Current Entity drop-down menu), click on Create New CSI on menu at left (or click on CSI tab, then Create Customer Support)
2. Click on Use CSI Wizard (on left)
3. Enter BOM Commission Date and Time (**required**)
4. Click on Next
5. Click on Distributor drop-down menu (**required**)
6. Click on Add a New Distributor
7. Enter the appropriate entity name in the Name box (**required**)
8. Click on Unit Owner for Category
9. Click on Save
10. Click on Next
11. Click on the Serial Number drop-down menu (**required**)
12. Click on the Available Parts drop-down menu
13. Click on the Appropriate BOM
14. Click on Select
15. Click on Next
16. Click on Next
17. Click on Unit Owner drop-down menu (**required**)
18. Click on Applicable Unit Owner or Add a New Unit Owner
19. Enter the appropriate entity name in the Name box (**required**)
20. Click on Save
21. Click on Location drop-down menu (**required**)
22. Click on Add a New Location
23. Enter company name in Company box (optional)
24. Enter facility/installation name in Description box (**required**)
25. Click on Save
26. Click on Next
27. Click on Contact Name drop-down menu
28. Click on Add a New Unit Contact
29. Enter First and Last names of contact in applicable boxes (**required**)
30. Click on Save
31. Click on Next
32. Click on Next
33. Click on Create

To create CSI records for additional serialized BOMs do the following:

1. With the initial BOM displayed, click on Duplicate
2. In the New CSI Report change the Commission Date/Time as appropriate
3. Click on the Serial Number drop-down menu
4. Click on the Available Parts drop-down menu
5. Click on the appropriate BOM
6. Click on Select
7. Change the Location, if necessary, by clicking on the Location drop-down menu or clicking on Edit
8. Change the Contact Name, if necessary, by clicking on the Contact Name drop-down menu or clicking on Edit
9. Click on Create

Note that if operation of a system is to be suspended for a lengthy period of time it can be excluded from reliability analyses by entering a decommission date on the CSI record. When the system is to be returned to service a new CSI record is created for the same serialized system.

The CSI is also used to specify the “system hours” and analysis date when data is to be exported for reliability growth analysis using RGA™ (Section 11.2).

6. INCIDENT TRACKING UTILITY

The Incident Tracking Utility allows authorized users to record reliability-related system-level and component-level events (i.e., hardware or software failures, system disruptions, preventative maintenance outages, hardware/software upgrades, etc.). Incident Tracking Utility terminology and menu option definitions can be found in the Appendix.

6.1. Creating Incident Records

To create incident records, do the following:

1. From Home Page (ensure appropriate Entity is selected from Current Entity drop-down menu), click on Incidents tab (or click on Create New Incident on menu at left)
2. Select Serialized Incident Type
3. Click on BOM Level 1 Part Serial Number drop-down menu
4. Click on Available Parts drop-down menu
5. Click on applicable BOM
6. Click on Select
7. Click on Next
8. Complete Incident Wizard for required entries (in red); completion of Incident Wizard opens an event record in Incident Tracking Utility
9. Enter additional event information in Incident Tracking Utility using information provided in Appendix – XFRACAS™ Terminology (note that times are entered using a 24-hour clock, as an example 14:00 instead of 2:00 P.M.)
10. Click on Save

Note: the System Down Event box in the incident record should be checked for any inverter incident caused by faults within the inverter that result in lost kilowatt-hours. This allows a proper sorting of data for exporting to RGA™ for repairable systems analysis (see Failure Type discussion in Appendix).

A Note about Time Zones

Incident record time fields include a time zone field. All times are saved in the database using Coordinated Universal Time (UTC), sometimes equated with Greenwich Mean Time (GMT). This allows users in various time zones to log and view events accurately and easily. The system administrator (i.e., **SUPERUSER**) should specify the appropriate time zone setting for each entity as follows:

1. From Home Page, click on Admin Home
2. Click on Preferences tab
3. Click on System Preferences
4. Scroll down to Time Zone Preferences
5. Click on Default GMT Offset for New Users drop-down menu
6. Click on appropriate time zone offset for entity
7. Click on Save

For example, if an incident record is created in Albuquerque, NM and later referenced in Kuala Lumpur, Malaysia, the time difference could cause confusion. Assume an incident occurs on March 8, 2006 at 10:30 PM in Albuquerque and is recorded at 2:38 PM on March 9, 2006. These times are saved in the database as “2006-03-09 05:30” and “2006-03-09 21:38”, respectively. Since Albuquerque, NM is located in time zone GMT-7, seven hours have been added to each date/time to get the UTC time (during daylight savings time offset is 6 hours).

6.2. Updating Incident Records

Incident records can be opened and updated at any time by doing the following:

1. From Home Page (ensure appropriate Entity is selected from Current Entity drop-down menu), click on Quick Search Utility at left
2. Select Incident #
3. Enter incident ID number in the Enter ID Number box
4. Click on GO

Replacement parts are entered into incident records as follows:

1. Display applicable incident record (see above)
2. Scroll to Incident Repair Information section of record
3. Click on Repair or Replace Parts
4. Expand BOM
5. Click on part to be replaced
6. Click on Replace Part
7. Click on (Replaced Part) Failure Type drop-down menu
8. Click on applicable menu option
9. Click on (Replaced Part) Disposition drop-down menu
10. Click on applicable menu option
11. Enter (Replaced Part) Run Hours (same as Clock Hours)
12. Enter (New Part) Serial Number of replacement part
13. Enter New Part starting age (zero assumed if no entry; that is, part is as good as new)
14. Click on Save
15. Click on Save
16. Click on OK

The Incident Status History link in the Incident Disposition section of the incident record allows users to view changes in incident status for a specific incident record.

When an incident is finally closed out in XFRACAS™ it is very important that the incident be properly characterized with respect to Incident Category and Failure Type, as the combination of these choices determines whether the incident is treated as a failure (chargeable) or as a suspension (non-chargeable) in data exports to Weibull++™.

6.3. Incident Summary Report

To view/print incident summary reports do the following:

1. From Home Page (ensure appropriate Entity is selected from Current Entity drop-down menu), click on Reports at left
2. Click on Incident General Summary at left
3. Click on Excel to print an Excel spreadsheet summary report

7. INCIDENT IMPORT TEMPLATE

The purpose of the XFRACAS™ Incident Import Template is to enter historical performance data into the PVROM database. The incident import template is a Microsoft Excel file (XFRACASImportTemplate_Incident.xls) located in the AdminApp folder (Section 10). **Caution: if using a Microsoft Excel spreadsheet other than the Incident Import Template, the spreadsheet must exactly mimic the Incident Import Template, including text formatting of all data columns.** Since this data is to be used for reliability/availability analysis, at minimum events resulting in a loss of power generation (kWh loss) should be captured in the template. Non-power loss events can be captured as well, but it must be recorded as a zero kWh loss. **Note: to import incident data to the production database the DataSource must be db41snlnt\pr (Section 10).**

The Incident Import Template consists of six (6) Excel worksheets, but only the Incident, Repair Replace, and Details worksheets are relevant for importing data to the PVROM database. Data for importing must be entered in the appropriate worksheet and must be text formatted for all worksheets (i.e., Incident, Repair Replace, and Details). Copy/paste operations may change entry formatting, so to get numerical entries (i.e., number, date, time, etc.) in text format ensure that an apostrophe (') is placed at the beginning of such entries.

7.1. Incident Worksheet (Figure 6 - Figure 11)

Required incident information is indicated by red text in the column headings. Note that the text in the first two column headings is pink indicating that one of the two columns (but not necessarily both) must have data entries. For legacy (historical) data it is suggested that I-xxx be used for the Unique Identifier, where “I” would be an appropriate PV system identifier and xxx a numerical incident counter.

For example, an incident for a Test PV system could have a unique identifier as “T-1.” “T” would be the system identifier (for Sandia in this case) and “1” is the first incident appearing in the spreadsheet. However, strict ordering is not needed in the designation of a Unique Identifier, just consistency in identification method.

Alternatively, incidents can simply be entered in numerical order (i.e., 1, 2, 3, etc.) in the Incident ID column. Note: regardless of the Unique Identifier/Incident ID entries in the incident worksheet, incident numbers are assigned in numerical order as incident data is entered into the PVROM database. Columns having black text headings do not require data entries. However, default data is provided for Reporting Date and System Status if those columns are left blank. Note: if an Incident Title is provided (column 3), this will be the preferred display over the Unique Identifier/Incident ID in the incident record.

The Reported By, BOM Level 1 Part Number, Level 1 Part Serial Number, BOM Level 2 Part Number, Level 2 Part Description, and Responsible Individual entries must be exact matches.

- Reported By entries must exactly match user login IDs as contained in the XFRACAS System Wide Information template for each user (e.g., John Q. Doe’s SON login ID is

JQDOE). Note that login IDs for the development infrastructure (see Section 15) are preceded by SANDIA\ (e.g., John Doe's SRN login ID is SANDIA\JQDOE)

- BOM part numbers and part serial numbers must exactly match numbers in the bill of materials (BOM).
- The Level 2 Part Description entry, if used, must exactly match the part description entry in the BOM.
- Responsible Individual entries must exactly match the login ID of the individual (e.g., JQDOE). Note: assigning a responsible individual to the top level of the BOM automatically assigns all parts beneath the top level to this individual. Then responsible individuals do not need to be assigned to every item in the BOM.

Date column entries must be entered in mm/dd/yy format. If times are also available the date/time entry format is mm/dd/yy hh:mm:ss: XM (where X stands for A [morning] or P [afternoon]). Note that there must be a single space between the date and the time, a colon following the seconds, a single space between the time and the AM/PM, and the AM or PM must be in capital letters. Note also that the time should be specified as hh:mm:00 since seconds is not a necessary level of detail and that the time is specified with respect to a 12-hour clock, not a 24-hour clock (hence the need for AM or PM).

Incident Status entries must exactly match entries in the Incident Tracking Utility Incident Status menu (see Appendix for menu options and definitions).

20 characters		100 characters	20 characters	Date/Time	Date/Time	Number
Unique Identifier	Incident ID	Incident Title	Reported By	Occurrence Date	Reporting Date	Repair Duration

Figure 6. Incident Import Template – Incident Worksheet

20 characters	20 characters	20 characters	20 characters	10 characters	75 characters	Y or N	Y or N	Date/Time
BOM Level 1 Part Number	Level 1 Part Version	Level 1 Part Serial Number	BOM Level 2 Part Number	Level 2 Part Version	Level 2 Part Description	Under Warranty	Customer Requested Feedback	Service Response Date

Figure 7. Incident Import Template – Incident Worksheet (cont.)

100 characters	50 characters	50 characters	50 characters	50 characters	50 characters	2000 characters
Responsible Individual	Incident Status	System Status	Incident Category	Report Type	Audience Restriction	Description of Incident

Figure 8. Incident Import Template – Incident Worksheet (cont.)

Date/Time	Date/Time	2000 characters	Date/Time	Date/Time	2000 characters
Target Date	Restored to Duty Date	Incident Resolution	Target Date	Service Completed Date	Initiating Event

Figure 9. Incident Import Template – Incident Worksheet (cont.)

Date/Time	Date/Time	2000 characters	Date/Time	Date/Time
Target Date	Completed Date	Additional Comments	Commissioning Date	Completed Date

Figure 10. Incident Import Template – Incident Worksheet (cont.)

Number	Number	Number
Clock Hours	Number of Starts	kWh Loss

Figure 11. Incident Import Template – Incident Worksheet (cont.)

System Status entries, if used, must exactly match entries in the Incident Tracking Utility System Status menu (see Appendix for menu options and definitions).

Incident Category entries must exactly match entries in the Incident Tracking Utility Incident Category menu (see Appendix for menu options and definitions). Note that additional incident category options can be added to the menu if necessary, but they will not apply to data already in the database.

Report Type entries must exactly match entries in the Incident Tracking Utility Incident Report Type menu (see Appendix for menu options and definitions).

Description of Incident is a required entry in the template, but is not an exact matching field. This entry should be as detailed as possible, but cannot exceed 2000 characters.

Incident Resolution must be either “repaired” or “replaced” (note that a reset action constitutes a repair). If the entire BOM Level 2 part is replaced, then “replaced” is the proper entry. If the part is repaired (even if internal components of the part are replaced), then “repaired” is the proper entry.

Entries for the following data fields are desired for importing data into the PVROM database:

- Unique Identifier (col. 1)
- Reported By (col. 4)
- Occurrence Date/Time (col. 5)
- Repair Duration (col. 7)*
- BOM Level 1 Part Number (col. 8)
- Level 1 Part Serial Number (col. 10)
- BOM Level 2 Part Number (col. 11)
- Level 2 Part Description (col. 13)
- Service Response Date/Time (col. 16)*
- Responsible Individual (col. 17)
- Incident Status (col. 18)*

- System Status (col. 19)*
- Incident Category (col. 20)*
- Report Type (col. 21)*
- Description of Incident (col. 23)
- Restored to Duty Date/Time (col. 25)*
- Incident Resolution (col. 26)
- Service Completed Date/Time (col. 28)*
- Initiating Event (col. 29)
- Commissioning Date (col. 33)*
- Clock Hours (col. 35)*
- kWh Loss (col. 37)*

* See Appendix for applicable definition/options

Note that Commissioning Date and kWh Loss data will need to be entered in the Details Worksheet (Section 7.3) for importing into the PVROM database, but entering the data here will make it easier to copy and paste into the Details Worksheet prior to sorting (see Figure 15).

Note that entries are required for the following data fields in order to import any data into the PVROM database using the XFRACAS™ Incident Import Template (i.e., these are the minimum number of fields that require data entries):

- Unique Identifier OR Incident ID (col. 1 or col. 2)
- Reported By (col. 4)
- Occurrence Date/Time (col. 5)
- BOM Level 1 Part Number (col. 8)
- BOM Level 2 Part Number (col. 11)
- Responsible Individual (col. 17)
- Incident Status (col. 18)
- Incident Category (col. 20)
- Report Type (col. 21)
- Description of Incident (col. 23)

7.2. Repair Replace Worksheet (Figure 12, Figure 13)

This worksheet needs to be completed for all entries in the Incident worksheet for which the incident resolution was either repaired or replaced. Required information is indicated by **red** text in the column headings. Note that the text in the first two column headings is **pink** indicating that one of the two columns (but not necessarily both) must have data entries.

Unique Identifier (or Incident ID) column entries must exactly match those in the Incident worksheet and must be in the same order.

The Item Order column **must** be filled in. The entries in this column indicate the order in which the performance of repair/replace actions is to be considered within a single incident. If there are

several repair/replace line items for a single incident, specify Item Order as a sequential, increasing number beginning at 1.

Old Part Number is the BOM Level 2 Part Number of the repaired/replaced part and must be an exact match.

Old Serial Number is the BOM Level 2 Part Serial Number of the repaired/replaced part and must be an exact match.

	20 characters	Number	20 characters	10 characters	100 characters	50 characters
Unique Identifier	Incident ID	Item Order	Old Part Number	Old Part Version	Old Serial Number	Failure Type

Figure 12. Incident Import Template – Repair Replace Worksheet

50 characters	50 characters	50 characters	Date/Time	20 characters	10 characters	100 characters	Number
Disposition	RMA	Sales Order Number	RMA Date Received	New Part Number	New Part Version	New Serial Number	Quantity

Figure 13. Incident Import Template – Repair Replace Worksheet (cont.)

Failure Type entries must exactly match one of the following options (see Appendix for Failure Type definitions):

- Non-inverter Inoperable – PM
- Non-inverter Inoperable – CM
- Non-inverter Inoperable – GI
- Non-inverter Inoperable – LI
- Non-inverter Inoperable – OI
- Inverter Inoperable – PM
- Inverter Inoperable – CM
- Inverter Inoperable – GI
- Inverter Inoperable – LI
- Inverter Inoperable – OI

Disposition column entries must match the corresponding entries in the Incident Resolution column of the Incident worksheet (i.e., “repaired” or “replaced”).

For repaired parts the New Part Number (heading in blue) should be left blank. For replaced parts the New Part Number entries are the same as the Old Part Number entries (i.e., BOM Level 2 Part Number).

For repaired parts the New Serial Number (heading in blue) should be left blank. For a replaced part a new serial number must be provided.

Note: prior to importing historical incident data involving part replacements, the appropriate replacement part serial numbers and replacement dates must be entered into the applicable BOM (Section 3).

7.3. Details Worksheet (Figure 14, Figure 15)

Mapping of data not provided for in the Incident worksheet to incident record fields is accomplished with the Details worksheet. This additional data is entered into the worksheet with the associated incident record field ID. Required information is indicated by red text in the column headings. Note that the text in the first two column headings is pink indicating that one of the two columns (but not necessarily both) must have data entries.

Unique Identifier (or Incident ID) column entries must exactly match those in the Incident worksheet.

The following Detail Type IDs* are used for entering the associated data into incident records:

<u>ID</u>	<u>Detail Type</u>
766	AC kWh Loss
767	Commissioning Date
18	System Down Event (used for sorting export data to RGA™; see Failure Type discussion in Appendix)

A one (1) must be entered in the Level column.

Detail Value column entries are the values for the Detail Type (above).

***Note:** prior to importing historical incident details the fields “AC kWh Loss” and “Commissioning Date” will need to be created as these are custom fields. ID numbers 766 and 767 are *examples* of Detail IDs that could be assigned to the Detail Types. Section 14.4 provides instructions on how to create custom fields.

Data for the first Detail Type (AC kWh Loss) are entered in this worksheet for each Unique Identifier/Incident ID followed by the data for the second Detail Type (Commissioning Date) for

each Unique Identifier/Incident ID. For inverter chargeable-incident category events, a Y is placed in the Detail Value field. An example Details worksheet is shown in Figure 15.

	20 characters	20 characters	Number	100 characters	20 characters
Unique Identifier	Incident ID	Detail Type ID	Level	Detail Value	Detail Code

Figure 14. Incident Import Template – Details Worksheet

Unique Identifier	Incident ID	Detail Type ID	Level	Detail Value	Detail Code
T-1		766	1	560	
T-1		767	1	8/1/2002	
T-10		766	1	90	
T-10		767	1	8/1/2002	
T-11		766	1	350	
T-11		767	1	8/17/2001	
T-12		766	1	260	
T-12		767	1	12/14/2001	
T-13		766	1	144	
T-13		767	1	8/1/2002	
T-131		766	1	8	
T-131		767	1	08/01/02	
T-132		766	1	20	
T-132		767	1	10/29/03	
T-132		18	1	Y	
T-133		766	1	4623	
T-133		767	1	6/11/04	

Figure 15. Example Details Worksheet

8. REPORT UTILITIES

The utilities area on the left side of the Home Page allows the user to search for specific records by number and to open pre-defined queries (searches can also be initiated by clicking on the Search/Report tab and selecting My Search Page). Similarly, the left side of the Home Page allows the user to generate reports (which can also be generated by clicking on the Search/Report tab and selecting My Report Page).

For example, to perform a specialized incident record search do the following:

1. From Home Page (ensure appropriate Entity is selected from Current Entity drop-down menu), click on Search/Report tab
2. Click on My Search Page
3. Select Query Incident Reports from the XFRACAS Query Data Group List
4. Select the appropriate search parameters for the incident record search
5. Click on Search
6. Click on Excel to print an Excel spreadsheet summary report
7. Click on Save if the query is to be saved

The Open PRR Report Summary, Incident General Summary, and PRR General Summary reports on the left side of the interface are utilities specific to this interface. The Specialized Reports area, on the right side of the interface, allows the user to select the specific search criteria for each type of report. Selecting a specialized report from the list displays the search criteria below the list.

Generated reports open in a new window and display in a format that can be printed from the user's Web browser, saved as Excel spreadsheets and/or copied into other applications for further analysis.

The Dashboard Page is similar to the Report and Search interfaces and allows the user to generate data charts based on specified search criteria. The Dashboard Page is selected from the Search/Report tab. Selecting a Dashboard report from the list displays the search criteria below the list. The Monthly PRR Count, PRR Priority Pareto, and PRR Time Trend charts have a fixed output, while user-customized output can be generated for the other chart options.

9. CUSTOM QUERIES

The Custom SQL Statement option allows authorized users to create, save, and publish their own custom reports. In particular, the user can use SQL SELECT statements to extract data from XFRACAS™ tables into a report.

To Create a Custom Query (ADMIN user only)

From Home Page, click on Home tab

Click on Admin Home

Click on Search/Report tab

Click on Administrator Reports

Click on Custom SQL Statement in the Administrator Reports box

Type or paste custom SQL SELECT statements into the SQL Statement box

Click on Publish

Enter a name for the Custom Query

From the Select User Name drop-down menu select the applicable users for the query (select All if a public query is desired)

From the Publish Query As drop-down menu select Report

Click on Publish

To Edit a Custom Query (ADMIN user only)

From Home Page, click on Home tab

Click on Admin Home

Click on Search/Report tab

Click on Administrator Reports

Click on Custom SQL Statement in the Administrator Reports box

Click on Custom SQL Reports on left side of screen

Select the desired SQL Report

Click on Edit

Edit the SQL statements as necessary

Click on Save

To Run a Custom Query Report

From Home Page, click on the Search/Report tab

Select My Report Page

Click on Public Reports on left side of screen

Double-click on the desired report

To save the report, click on Excel

Report will open in Excel

PVROM Downtimes and Suspension Times Query

A customized SQL query was used to extract restoration times from incident records in XFRACAS for all components in the BOM in order to estimate off time distributions due to corrective maintenance (a.k.a. repair distributions). This custom query (Figure 16) exports data for every incident into Microsoft Excel. The exported data (illustrated in Figure 17 - Figure 19)

also includes inverter downtimes due to planned maintenance, grid-induced outages, and lightning-induced outages.

Specifying '1/1/2008 6:00:00 AM' in the 13th line of the Figure 16 SQL statements [i.e., DateDiff(hour, Incident.occurrence_dt, '1/1/2008 6:00:00 AM') as Add_Suspension_Time] extracts downtime and suspension time data through December 31, 2007. A different analysis date (e.g., 9/30/2009) would require specifying the next calendar day (e.g., '10/1/2009 6:00:00 AM') in this SQL statement. Note that to obtain SQL query data exports, RGATM data exports, and Weibull++TM data exports that include credit for operating time until a specified date of analysis, the system hours must first be updated in each CSI (see Section 11.2).

To make this query applicable to a specific entity, the number in the second-last SQL statement in Figure 16 [i.e., WHERE Incident.entity_id IN (2)] must be changed. The SQL statement number indicates the entity for which the query is being applied (1 for Entity 1, 2 for Entity 2, 3 for Entity 3, etc.). If a query of multiple entities' data is desired (e.g., entities 1, 2, and 3), then the appropriate SQL statement would be, WHERE Incident.entity_id IN (1,2,3). If a query of all entities' data is desired, then all entity numbers must be included in this SQL statement.

```
SELECT Incident.incident_id AS Unique_IR_Number, Incident.entity_display_id AS Incident_Number,
Incident.occurrence_dt AS Occurrence_Date, IDIncidentDescription.completed_dt AS Restoration_Date,
DateDiff(hour, Incident.occurrence_dt, IDIncidentDescription.completed_dt) as Restoration_Time,
Incident.serv_response_dt as Service_Response_Date,
IDRIncidentDescription.completed_dt AS Repair_Date,
DateDiff(hour, Incident.occurrence_dt, IDRIncidentDescription.completed_dt) as Repair_Time,
IFARevMaster.rev_item_nr + ':' + IFARevMaster.rev_item_dsc AS Responsible_Part,
ISNULL(I20_21.issue_dsc, '') AS Incident_Category,
IMP.serial_nr as Serial_Number,
I22_23.issue_dsc as Failure_Type,
UC.commission_dt as Commission_Date,
DateDiff(hour, UC.commission_dt, Incident.occurrence_dt) as Part_Clock_Time,
DateDiff(hour, Incident.occurrence_dt, '1/1/2008 6:00:00 AM') as Add_Suspension_Time
FROM Incident
LEFT OUTER JOIN IncidentDescription IDIncidentDescription on Incident.incident_id =
IDIncidentDescription.source_id
AND IDIncidentDescription.desc_type_id = 101
LEFT OUTER JOIN IncidentDescription IDRIncidentDescription on Incident.incident_id =
IDRIncidentDescription.source_id
AND IDRIncidentDescription.desc_type_id = 102
LEFT OUTER JOIN IncidentRespRevItemUser ON Incident.incident_id =
IncidentRespRevItemUser.incident_id AND IncidentRespRevItemUser.bcurrent = 1
LEFT OUTER JOIN RevMaster IFARevmaster ON IncidentRespRevItemUser.resp_rev_item_id =
IFARevMaster.rev_item_id
LEFT OUTER JOIN IncidentIssue II20_21 ON Incident.incident_id = II20_21.incident_id AND
II20_21.bCurrentIssue = 1
INNER JOIN Issue I20_21 ON II20_21.issue_id = I20_21.issue_id AND I20_21.issue_type_id IN (20,
21)
LEFT OUTER JOIN IncidentItem II ON Incident.incident_id = II.incident_id and II.item_order = 0
LEFT OUTER JOIN ItemMaster IM ON II.old_item_id = IM.item_id
```

```

LEFT OUTER JOIN IncidentItem IIP ON Incident.incident_id = IIP.incident_id and IIP.item_order <> 0
LEFT OUTER JOIN ItemMaster IMP ON IIP.old_item_id = IMP.item_id
INNER JOIN IncidentItemIssue II22_23 ON IIP.incident_item_id = II22_23.incident_item_id
INNER JOIN Issue I22_23 ON II22_23.issue_id = I22_23.issue_id and I22_23.issue_type_id IN (22, 23)
LEFT OUTER JOIN UnitCommissioning UC on IM.item_id = UC.item_id
LEFT OUTER JOIN RevMaster RM ON IM.rev_item_id = RM.rev_item_id
WHERE Incident.entity_id IN (2)
ORDER BY Incident.entity_display_id, IM.serial_nr + ': ' + RM.rev_item_dsc, Incident.occurrence_dt

```

Figure 16. Downtimes/Suspension Times SQL Query

Report Generated:
07/07/2011 01:34 PM

Unique IR Number	Incident Number	Occurrence Date	Restoration Date	Restoration Time
1	TEP-1	2/6/2003	2/8/2003 7:07	28
10	TEP-10	6/30/2003	7/1/2003	0
100	TEP-100	9/2/2004	9/3/2004	0
101	TEP-101	9/2/2004	9/3/2004	0
102	TEP-102	9/2/2004	9/3/2004	0
103	TEP-103	9/2/2004	9/3/2004	0
104	TEP-104	9/2/2004	9/3/2004	0
105	TEP-105	9/2/2004	9/3/2004	0
106	TEP-106	9/2/2004	9/3/2004	0

Figure 17. Downtimes/Suspension Times Query Results

Service Response Date	Repair Date	Repair Time	Responsible Part	Incident Category
N/A	N/A	N/A	DDS: DC Disconnect Switch	Unknown
N/A	N/A	N/A	MOD: PV Module	Hardware Failure
N/A	N/A	N/A	INV: Inverter	Planned Maintenance
N/A	N/A	N/A	INV: Inverter	Planned Maintenance
N/A	N/A	N/A	INV: Inverter	Planned Maintenance
N/A	N/A	N/A	INV: Inverter	Planned Maintenance
N/A	N/A	N/A	INV: Inverter	Planned Maintenance
N/A	N/A	N/A	INV: Inverter	Planned Maintenance

Figure 18. Downtimes/Suspension Times Query Results (cont.)

Serial Number	Failure Type	Commission Date	Part Clock Time	Add Suspension Time
DDS-9	Other-induced Suspension	8/1/2002 14:00	4549	42939
M-U8-74	Primary Failure	8/1/2002 14:00	8002	39486
INV-24	Preventative Maintenance Suspension	7/22/2004 14:00	1018	29166
INV-25	Preventative Maintenance Suspension	6/30/2004 14:00	1546	29166
INV-26	Preventative Maintenance Suspension	6/11/2004 14:00	2002	29166
INV-27	Preventative Maintenance Suspension	6/11/2004 14:00	2002	29166
INV-28	Preventative Maintenance Suspension	6/11/2004 14:00	2002	29166
INV-29	Preventative Maintenance Suspension	10/29/2003 14:00	7426	29166
INV-30	Preventative Maintenance Suspension	10/29/2003 14:00	7426	29166

Figure 19. Downtimes/Suspension Times Query Results (cont.)

10. ADMINISTRATIVE UTILITY

The XFRACAS™ Administrative Utility allows the database administrator(s) (i.e., SUPERUSER) to import data and manage resources (the text that appears throughout XFRACAS™). The Utility must be loaded on the user's SRN (Sandia Restricted Network) computer by running **SetupXFRACAS6_Admin_SQL.exe** (this file must be obtained through ReliaSoft Technical Support) and following the setup wizard instructions. Note: the SQL server name should be changed during setup from ENTERPRISE to db41snlnt\pr and this database is only accessible from the SRN. Executing the setup file installs a folder titled XFRACAS_AdminApp on the administrator's computer, which includes the Administrative Utility executable file (XFRACASAdmin.exe) and a folder titled Templates. The Templates folder includes the Parts Import Template (XFRACASImportTemplate_Parts.xls) for creating BOMs (Section 3) and the Incident Import Template (XFRACASImportTemplate_Incident.xls) for importing incident legacy data (Section 7).

Prior to executing the Administrative Utility, ensure that the XFRACAS DataSource file in the computer registry is identified as db41snlnt\pr by doing the following (**SUPERUSER only**):

1. Click on Start
2. Click on Run
3. Open regedit
4. Expand HKEY_LOCAL_MACHINE
5. Expand SOFTWARE
6. Expand Wow6432Node (this step applies only if using a 64-bit Windows OS and should be skipped if using a 32-bit OS)
7. Expand ReliaSoft
8. Expand XFRACAS
9. Open the Settings folder
10. Double-click on DataSource
11. If necessary, enter db41snlnt\pr in value data box
12. Click on OK
13. Close the Registry Editor

10.1. Data Import Function

When the Administrative Utility is started a Select Tool menu (Figure 20) appears. The Data Import function is used to import historical incident data as well as BOM data (templates and serialized systems) into XFRACAS™. The Resource Editor function can be used to edit various field names displayed in the Incident Tracking Utility. To import data (e.g., BOMs, legacy incident data, etc.), click on Data Import. The Import Data Type menu (Figure 21) will appear. To import BOMs, select Templates and Serialized Systems. To import legacy incident data, select Incident and click on OK. A Select Entities for Import window will appear. Click on the appropriate entity (i.e., entity associated with BOM or incident data), then click on OK. Locate and open the appropriate BOM or incident data Excel file, which will initiate the data import process. **Note: the Administrative Utility only accommodates *.xls files so a *.xlsx file will need to be converted to a *.xls file.**

When the data import process is completed a dialog box will appear stating that “The data from ‘*.xls’ has been properly imported.” Click on OK to complete the data import activity.

An import log is created during the data import process. If errors are encountered during this process details can be found in this log, which is necessary for obtaining the help of ReliaSoft technical support personnel in determining the source and resolution for data import problems. This log is located in the XFRACAS folder on the computer’s hard drive. For example, in Windows 7 this log can be found using the following link: [C:\ProgramFiles\(x86\)\ReliaSoft\XFRACAS\AdminApp](C:\ProgramFiles(x86)\ReliaSoft\XFRACAS\AdminApp). Individual errors can be identified in the log by doing a search for Error.

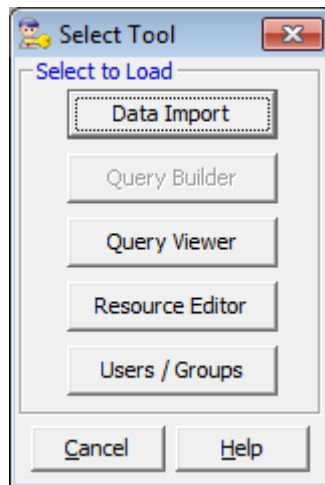


Figure 20. Administrative Utility Select Tool

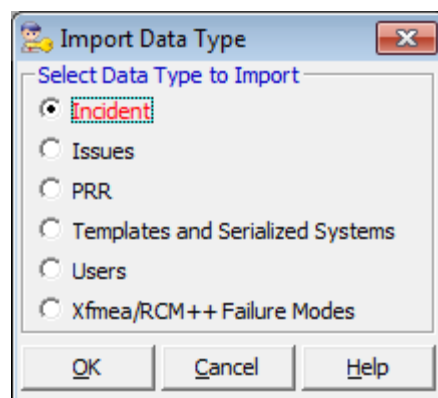


Figure 21. Administrative Utility Data Import Menu

10.2. Resource Editor Function

Some Incident Tracking Utility display field names can be edited using the Manage Detail Fields Utility (Section 14.4). Others can be edited using the Resource Editor by searching for either the Resource ID or Default Text. However, since a default text may have multiple Resource IDs, one may want to find the Resource IDs associated with the specific field names that are to be changed prior to using the Resource Editor. This can be accomplished as follows (**SUPERUSER only**):

- From Home Page click on Home tab
- Click on Admin Home
- Click on the Preferences tab
- Click on System Preferences
- Scroll down in the Boolean Preferences window to XFRACAS – Display Debug IDs
- Click on True
- Click on Save
- Click on OK
- Scroll back to top of screen
- Click on Home tab
- Click on XFRACAS Home
- Select Incident # in the Utilities window on the left
- Enter a known incident ID number
- Click on Go
- Find Resource IDs in the incident record for each of the field names to be changed

The following instructions should be followed for editing XFRACAS display field names (**SUPERUSER only**).

- Execute Administrative Utility
- Click on Resource Editor
- On right side of screen click on drop-down menu displaying the words “No filter”
- Click on Filter by Resource ID (or on Filter by Default Text, depending on how you want to search for the field name to be edited)
- Enter Resource ID in the Start ID and End ID boxes (or the default text in the Filter box)
- Click on OK
- From list of displayed entries right-click on entry to be changed
- Click on Edit
- Uncheck Default Text box
- Edit Display Text
- Click on Save
- Click on OK
- Close Resource Editor
- Close Admin Utility

The following Incident Tracking Utility display names were edited for the PVROM database (note that the corresponding names in Weibull++TM and RGATM may also need to be changed).

<u>Resource ID</u>	<u>Original Field Name (Incident Record Location)</u>	<u>Edited Field Name</u>	<u>Name Common to Weibull++TM / RGATM</u>
11020	System Configuration (incident data summary)	BOM Level 1 Part S/N, Description	No
11034	Responsible Part (incident data summary)	BOM Level 2 Part Number	No
11213	Run Hrs (incident data summary)	System Hrs	No
11048	Serial Number (System/Component Information window)	BOM Level 1 Part Serial Number	No
11051	Part Number (System/Component Information window)	BOM Level 1 Part Number	No
11072	Responsible Part (Incident Disposition window)	BOM Level 2 Part Number	No
11135	Initial Failure Analysis (Incident Repair Information window)	Initiating Event	No

11. EXPORTING XFRACAS™ DATA

The XFRACAS™ Analysis Page interface allows the user to export data to a ReliaSoft software product (e.g., Weibull++™ or RGA™) for further analysis, as long as the application is installed on the user's computer. To open the Analysis Page from the Home Page, click on the Search/Report tab and select My Analysis Page. The area on the right side of the interface allows the user to select the specific software product to export the XFRACAS™ data to and the utilities are displayed on the left side of the interface.

11.1. Weibull++™ Data

Weibull++™ analysis allows one to generate reliability distributions for components in the PV system Bill of Materials. To export data to Weibull++™, select one or more system components from the System Component field by clicking on the + sign to expand the system BOM. To export all serialized parts of the selected component type(s), select **All** in the Manufacturing Code field (this is also the default when nothing is selected). Make the appropriate selections in the Unit Owner and Location fields. The appropriate time metric for PV system reliability analyses is **Clock Hours**. Click **Launch** to activate the software and analyze the data. The generated file must be saved to a desktop, hard drive, storage area, etc. before it can be opened in Weibull++™. The combination of Incident Category and Failure Type determines if an incident is treated as a failure or as a suspension when it is exported to Weibull++™ (see Classification of Incident Category and Failure Type Menu Options in Appendix).

11.2. RGA™ Data

RGA™ analysis (i.e., repairable systems analysis) allows one to assess the reliability growth of PV systems. Since system reliability growth is strongly correlated with inverter reliability growth, the latter then becomes the focus of RGA™ analysis. Prior to exporting an RGA™ data file the system hours for data analysis must be specified in the applicable CSI. To accomplish this, open the CSI, click on Update System Hours in the Utilities menu on the left, enter the operating hours from system commissioning to analysis date in the System Hours box, enter the analysis month, day, and year, and then click on Save.

To export data to RGA™, select the desired system in the System Component field. To export all serial numbers associated with the selected system, select **All** in the Serial Number field. Make the appropriate selections in the Unit Owner and Location fields. The appropriate time metric for PV system reliability analyses is **Clock Hours** and the appropriate Analysis Type is **Repairable Systems**. Click on the radio button for “by Commission Date” and on the “Include Non-Chargeable incidents in the analysis?” checkbox. Click **Launch** to activate the software and analyze the data. The generated file must be saved to a desktop, hard drive, storage area, etc. before it can be opened in RGA™.

12. PROBLEM RESOLUTION REPORT (PRR)

The Problem Resolution Report (PRR) Tracking Utility allows the management of problem issues by associating individual reported incidents with a single report that can be tracked and resolved. Although this feature of XFRACAS™ is not being used in the PVROM activity, it is a feature that may be useful to industry partners and is therefore addressed here. Create PRR records as follows:

From Home Page, click on PRR tab, then select Create PRR (or click on Create New PRR in menu at left)

In the **Define** step do the following:

- Enter a title for the PRR
- Assign a PRR owner and creator
- Assign a priority
- Click on Create

In the **Measure** step do the following:

- Enter a problem description
- Click on Assign/Remove Incidents in Associated Incident Reports field
- Click on Filter
- Check applicable incident box and click on Save
- **Note: if problem description is insufficient to determine appropriate corrective actions, then do the following:**
 - Click on Create New Action Item
 - Assign a responsible person for this action item from the Assigned To drop-down menu
 - Select an action category
 - Assign a due date
 - Enter a description of the action item
 - Click on Create
 - Click on Save
- **Note: when problem description action item has been completed, do the following:**
 - Select person who completed action item from Completed By drop-down menu
 - Click on the clock icon to the right of the Completed Date field to automatically enter the current date and time
 - Click on Save

In the **Improve** step do the following:

- Enter a corrective action description
- Click on Create New Action Item
- Assign a responsible person for this action item from the Assigned To drop-down menu
- Select appropriate action category

- Assign a due date
- Enter a description of the action item
- Click on Create
- Click on Save
- **Note: when corrective action item has been completed, do the following:**
 - Select person who completed action item from Completed By drop-down menu
 - Click on the clock icon to the right of the Completed Date field to automatically enter the current date and time
 - Click on Save

In the **Control** step do the following:

- Enter a prevent recurrence description
- Click on Create New Action Item
- Assign a responsible person for this action item from the Assigned To drop-down menu
- Select Prevent Recurrence for action category
- Assign a due date
- Enter a description of the action item
- Click on Create
- Click on Save
- **Note: when prevent recurrence action item has been completed, do the following:**
 - Select person who completed action item from Completed By drop-down menu
 - Click on the clock icon to the right of the Completed Date field to automatically enter the current date and time
 - Click on Save

To get to the PRR Tracking Utility to update PRRs do the following:

- From Home Page click on Reports
- Click on Open PRR Report Summary
- Click on desired PRR Number

13. FAILURE ANALYSIS

The Failure Analysis Utility allows the specification of failure analysis details for parts that were replaced during an incident and then analyzed. Although this feature of XFRACAS™ is not being used in the PVROM activity, it is a feature that may be useful to industry partners and is therefore addressed here. To open the Failure Analysis Utility and create a new failure analysis report, click on the **New** link in the Failure Analysis Report section of the Repair or Replace Parts grid in the Incident Repair Information section of the Incident Tracking Utility (incident record).

The Failure Summary area at the top of the report displays the details of the parts that were replaced as a result of the incident. In the Failure Analysis Information section of the report, the Failure Type for a part that was replaced can be selected. If a failure modes and effects analysis (XFMEA™) has been performed on the part, the associated failure mode can be selected by clicking on **Add** to the right of the Failure Mode box. This opens the Failure Mode Utility, which allows the selection of failure modes or the addition of new failure modes. Failure mode data is organized in the following tree format based on the XFMEA™ process.

- Part Number
- Function
- Failure
- Effect
- Cause

Failure modes may be associated with one or more part numbers (if a failure mode is not associated with a part number, it will appear under part number “Unknown”). Select one or more failure mode issues using the **CTRL** key and click on **Save**.

To add new failure mode issues for a part (i.e., function, failure, effect, or cause) click on the **Add New** link to the left of the box. This opens the Failure Mode Issue Utility. Enter a name or code for the issue and a description in the appropriate boxes. Select the part number with which the failure mode is associated or, if the failure mode is not associated with a part number, select **Unknown**. The tree of associated failure mode issues will be displayed in the **Select a Parent Issue** box. Select the issue (i.e., function, failure, or effect) that the new issue is to fall under and click **Save** to create the new issue. This will result in a return to the Failure Mode Utility, where the new issue can be selected.

A description of the failure and associated consequences can also be entered in the appropriate boxes in the Failure Analysis Information section of the Failure Analysis Report.

14. XFRACAS™ ADMINISTRATOR FUNCTIONS

14.1. Creating Entities

To create Entities (**SUPERUSER only**):

1. From Home Page, click on Home tab
2. Click on Admin Home
3. Click on System tab
4. Click on Entities Configuration
5. Click on Create Entity at left
6. Type name of Entity in Long Name box
7. Type desired acronym in Short Name box
8. Type desired ID in Record Prefix box (this ID will prefix the incident number in displayed Entity incident records)
9. Select Active from drop-down menu in Entity Status box
10. Click on Save

Note: The Incident Category (Incident Category Chargeable and Incident Category Non-chargeable), Failure Type (Incident Failure Type Chargeable and Incident Failure Type Non-chargeable), Incident Report Type, Incident Status, and Incident System Status lookup lists for a new Entity should be checked to ensure that they are in accordance with the options given in the Appendix.

14.2. Managing User Groups

XFRACAS™ users must have a SON account. External users (i.e., industry partner users) must obtain a SON account through the SNL Password Administration organization (see Section 2.3).

To create user groups and manage user group membership (**SUPERUSER or ADMIN user group membership required for this management function**):

1. From Home Page (ensure appropriate Entity is selected from Current Entity drop-down menu), click on Home tab
2. Click on Admin Home
3. Click on Manage tab
4. Select Users
5. Click on User Groups
6. Select desired entity
7. Click on Select Group to Edit drop-down menu
8. Select Add a new User Group

To create a SUPERUSER group (**SUPERUSER only**):

9. Type SUPERUSER into Group Name box
10. Type SUPER END USER into Description box

11. Change user group permissions to Yes as follows:

- Incident – Allow System Template Modifications
- Portal – Edit Portal Preferences
- Reports – Access Reports Page
- Search – Access Search Page
- Search/Reports – My Queries Enabled
- Search/Reports – Public Queries Enabled
- Search/Reports – Query System Configurations Enabled
- Search/Reports – Quick Search Enabled
- All Administrative Permissions

12. Click on Create

13. Click on Manage Group Membership

14. Select appropriate names in the All Users box on the left

15. Click on forward transfer arrow to add User to User's Groups box

16. Click on Save

To create an ADMIN group (**SUPERUSER only**):

9. Type ADMIN into Group Name box

10. Type ADMINISTRATIVE GROUP into Description box

11. Change user group permissions to Yes as follows:

- Portal – Edit User Information
- Reports – Access Reports Page
- Search – Access Search Page
- Search/Reports – My Queries Enabled
- Search/Reports – Public Queries Enabled
- Search/Reports – Query System Configurations Enabled
- Search/Reports – Quick Search Enabled
- All Administrative Permissions except
 - Access/Update Action List Page
 - Access/Update Lookup List Page
 - Manage Admin Permissions
 - Manage Criticality Fields
 - Manage Detail Fields
 - Manage Entities
 - Manage User Groups
 - System Preferences

12. Click on Create

13. Click on Manage Group Membership

14. Select appropriate names in the All Users box on the left

15. Click on forward transfer arrow to add User to User's Groups box

16. Click on Save

To create a USER group (**SUPERUSER and ADMIN user only**):

9. Type USER into Group Name box

10. Type STANDARD END USER into Description box

11. Change user group permissions to Yes as follows:

- Project Owner
- PRR Owner
- All Action entries
- Allow Sending XFRACAS Data via E-mail
- Analysis – Access Analysis Page
- All CSI entries
- Dashboard – Access Dashboard Page
- Delete Associated File
- Failure Analysis – Update/Edit Failure Analysis
- All Incident entries except Allow System Template Modifications
- All Incident/PRR entries
- All Menu entries
- All Project entries
- All PRR entries
- Reports – Access Reports Page
- Search – Access Search Page
- Search/Reports – My Queries Enabled
- Search/Reports – Public Queries Enabled
- Search/Reports – Query System Configurations Enabled
- Search/Reports – Quick Search Enabled
- All Warning entries
- Admin – Edit All Custom SQL

12. Click on Create

13. Click on Manage Group Membership

14. Select appropriate names in the All Users box on the left

15. Click on forward transfer arrow to add User to User's Groups box

16. Click on Save

14.3. Managing Users

To add users (**SUPERUSER or ADMIN user group membership required for this management function**)

1. Admin Home
2. Click on Manage tab
3. Click on Users

4. Select desired entity
5. Enter user information into System Wide Information template (First Name, Last Name, E-Mail Address, and Login ID are required entries)
 - Click on Entities
 - Click on desired entity in All Entities box
 - Click on forward transfer arrow to add entity to User's Entities box
 - Click on Save
 - Click on Create
6. Enter user information into [Entity] Information template
 - Click on User Groups
 - Click on Admin or User, as applicable, in All Groups box
 - Click on forward transfer arrow to add Admin and/or User to User's Groups box
 - Click on Save
7. Change permissions to Yes, as appropriate, for:
 - Project Owner
 - PRR Owner
 - All Action entries
 - Allow Sending XFRACAS Data via E-mail
 - Analysis – Access Analysis Page
 - All CSI entries
 - Dashboard – Access Dashboard Page
 - Delete Associated File
 - Failure Analysis – Update/Edit Failure Analysis
 - All Incident entries except Allow System Template Modifications
 - All Incident/PRR entries
 - All Menu entries
 - All Project entries
 - All PRR entries
 - Reports – Access Reports Page
 - Search – Access Search Page
 - Search/Reports – My Queries Enabled
 - Search/Reports – Query System Configurations Enabled
 - Search/Reports – Quick Search Enabled
 - All Warning entries
 - Access/Update Responsible Individual Page

14.4. Editing Incident Tracking Utility Detail Fields

Some Incident Tracking Utility display field names can be edited using the Resource Editor (Section 10.2). Others can be edited using the Manage Detail Fields Utility. To access this utility (**SUPERUSER only**):

1. From Home Page, click on Home tab
2. Click on Admin Home
3. Click on Preferences tab
4. Click on Detail Field Names
5. Scroll down to Incident Fields window
6. Click on green ADD button to add fields, blue EDIT button to edit fields, or red DEL button to delete fields

To capture labor costs in the incident record four new fields were added to the Incident Repair Information window and given display order positions 1-4 as follows:

- Labor Hours – Professional (display order 1)
- Labor Hours – Skilled (display order 2)
- Labor Hours – Unskilled (display order 3)
- Non-labor Cost (display order 4)

The display order of the Associated Files field in the Incident Repair Information window was changed to 5 to accommodate these new fields.

In addition to the customer labor fields, another field is added called “AC kW Hours Lost” and “Commissioning Date.” As noted in Section 7.3 these fields must be created before historical incident data can be entered into the Incident Details Worksheet. Once the fields are created the Detail Type IDs will need to be recorded. To find these IDs turn on the “Display Debug IDs.”

1. From Home Page click on Home tab
2. Click on Admin Home
3. Click on the Preferences tab
4. Click on System Preferences
5. Scroll down to the Boolean Preferences window
6. Find “XFRACAS - Display Debug IDs” and click on “True”
7. Click on the Save button on the lower left hand side of the screen
8. Click on the Preferences tab
9. Click on Detail Field Names
10. Scroll down to Incident Fields window

Incident Fields [33003]

[Add Space](#) [Del Space](#) [ADD](#) [EDIT](#) [DEL](#)

[18] * System Down Event: (System/Component Information [11046], 1) ☐

[750] Fault Codes: (Incident Disposition [11061], 1) [Del](#)

[762] Labor Hours - Professional: (Incident Repair Information [11084], 1)

[764] Labor Hours - Unskilled: (Incident Repair Information [11084], 3)

[755] Associated Files: (Incident Repair Information [11084], 5)

[766] AC kW Hours Lost: (Incident Details [11085], 1)

[19] * Ass'y Serial No: (System/Component Information [11046], 1)

[21] * Project: (System/Component Information [11046], 8)

[22] * Program-PIA: (System/Component Information [11046], 9)

[763] Labor Hours - Skilled: (Incident Repair Information [11084], 2)

[765] Non-labor Cost: (Incident Repair Information [11084], 4)

[767] Commissioning Date: (Incident Details [11085], 2)

[20] * Contract No: (System/Component Information [11046], 7)

Figure 22. Incident Field Preferences with Display Debug IDs set to “True”

As shown in Figure 22 the Detail IDs for “AC kW Hour Lost” and “Commissioning Date” are 766 and 767 respectively. The Display Debug IDs can be “turned off” by going back to System Preferences and clicking on “False” of “XFRACAS - Display Debug IDs.”

14.5. Setting System Preferences

Various XFRACAS™ system preferences can be specified for each Entity by means of the Manage Administrative Preferences Utility. To access this utility (**SUPERUSER only**):

1. From Home Page click on Home tab
2. Click on Admin Home
3. Click on the Preferences tab
4. Click on System Preferences
5. Scroll down to the Boolean Preferences window
6. Click on title to open window
7. The various functions in this window can be “turned on or off” by clicking on True or False and then clicking on Save

Check to ensure that the following functions are “turned off” (False) for the PVROM database:

- Incident – Always Auto-calculate Time Metric 1
- Incident – Display Time Metric 2
- Incident – Display Time Metric 3

The following functions should be checked to ensure that they are “turned on” (True) for each Entity:

- Incident – Display Calculated Downtime
- Incident – Display Calculated Response Time
- Incident – Display Repair Duration
- Incident – Display Repair/Replace Parts
- Incident – Display Service Response Time/Date
- XFRACAS – Display Time With Date Fields

Similarly, the following functions should be checked for each Entity in the Target and Completed Dates window to ensure the status is as shown:

- Incident – Description of Incident; Show Target Date (False)
- Incident – Description of Incident; Show Completed Date (True)
- Incident – Incident Resolution; Show Target Date (False)
- Incident – Incident Resolution; Show Completed Date (True)
- Incident – Initiating Event; Show Target Date (False)
- Incident – Initiating Event; Show Completed Date (False)

14.6. Specifying Lookup List Options

Options for various lookup lists can be specified for each Entity by means of the Manage Lookup Lists Utility. To access this utility (**SUPERUSER only**):

1. From Home Page click on Home tab
2. Click on Admin Home
3. Click on the List tab
4. Click on System General Lookup Lists
5. Scroll down to the desired lookup list window
6. Click on title to open window
7. Add, delete, or edit window entries to specify the menu options shown in the Appendix for Incident Category, Failure Type, Incident Status, Report Type, and System Status
8. Click on Save when entries for each lookup list have been appropriately specified

15. SOFTWARE UPDATES

Software updates should be installed on the development infrastructure and validated prior to installation on the production infrastructure. The development and test infrastructure uses database server db13snlnt\dv.

Development Infrastructure:

IIS Server: WS53SNLNT – <http://xfracas-d.sandia.gov>

Server administrator: Amy Schwebke (505-284-6442)

Database Server: DB13SNLNT\DV

Server administrator: Mike Seyl (505-845-7980)

This application does not require a password. To ensure that database server db13snlnt\dv is accessible while using this application:

Click on Start

Click on Run

Open regedit

Expand HKEY_LOCAL_MACHINE

Expand SOFTWARE

Expand Wow6432Node (this step applies only if using a 64-bit Windows OS and should be skipped if using a 32-bit OS)

Expand ReliaSoft

Expand XFRACAS

Open the Settings folder

Double-click on DataSource

Enter db13snlnt\dv in value data box

Click on OK

Close the Registry Editor

Note: user IDs for the development application must be preceded by SANDIA\ (e.g., SANDIA\JQDOE). This is important to remember when performing incident data imports (Section 7.1) to the development database for validating software updates.

The production infrastructure uses database server db41snlnt\pr and is for production purposes only (i.e., entering PV system performance data for participating partners). Only install software updates on this infrastructure after first validating their performance on the development infrastructure.

Production Infrastructure:

IIS Server: WS04SNLNT – <https://xfracas.sandia.gov>

Server administrator: Amy Schwebke (505-284-6442)

Database Server: DB41SNLNT\PR

Server administrator: Mike Seyl (505-845-7980)

To ensure that database server db41snlnt\pr is accessible while using this application, follow the instructions above (with the exception that db41snlnt\pr is entered in the value data box).

16. DATABASE BACKUPS

A restoration point was created for the development database on November 9, 2011, which is accessible at H:\dump\DV\saveDump\xfracas_db_CLEAN_DB_2011-11-9-9-00. This backup will restore the development database to its initialized condition prior to the entry of any BOM or incident data.

A backup can be used to restore the production database to a previous condition. **Note that restoring the production database to a previous condition will result in data being lost that may not be recoverable.** Nevertheless, it is prudent to make periodic backups of the production database. As a minimum, this database (db41snlnt\pr) should be backed up once a month. First create a folder (e.g., JQDOE) in the public dropzone where the backup file can be placed and retrieved (ensure that this folder is still in the public dropzone prior to requesting a backup). To request a database backup click on the following link (URL may need to be copied and pasted in Web browser to complete service request):

https://oas.sandia.gov:8250/dba_app/service_request.main_menu

Click on Create New Service Request and provide the following information.

Service Type: Select COTS Application Software Upgrade from drop-down menu

Short Description of Work: db41snlnt\pr database backup

Date & Time Needed: Provide desired data and time

Project: Select Photovoltaic Reliability Database from drop-down menu

Database Instance: Select db41snlnt\pr from drop-down menu

Work Description: Perform backup of ds41snlnt\pr and place file in \\dropzone\public\xxxxxx (where xxxxxx is the name of the public dropzone folder in which the backup file is to be placed)

Click on Submit Request

When the backup file has been placed in the designated public dropzone folder, copy the file to R:\fs08836w2 (PV common read-only folder), where it can be retrieved if needed. This be done as soon as possible as files will be automatically removed from the public dropzone within 7 to 10 days of creation.

APPENDIX: XFRACAS™ TERMINOLOGY

System Status Menu Options

- Unknown
 - It is unclear if the system is fully producing power or if it requires service, maintenance
- Running
 - The system is producing power as expected
- Decreased AC output
 - The system is producing power at some degraded level; requires service such as cleaning, single inverter repair, module needs to be replaced, blown fuse, etc.
- Down – waiting on engineering
 - The system is not producing any power or minimal power; the problem still requires diagnosis or trouble-shooting
- Down – waiting service
 - The system is not producing any power or minimal power; the problem has been diagnosed, but the part or crew/manpower is on order
- Decommissioned
 - No longer available for power production; customer/owner has chosen to take this system or part of the system offline

Incident Status Menu Options

- Open
 - The incident has occurred and has been logged. No action has been taken
- Under review
 - The incident is being investigated by engineering or other staff
- Closed
 - The problem has been resolved and the root cause has been identified and corrected. The system is fixed and is running again
- Closed – insufficient data
 - The system has been reset and is up and running, but the root cause has not been identified
 - Example: The inverter tripped and was reset, but the cause of the trip was not identified. A ground fault could not be found

Report Type Menu Options

- Planned field event
 - Preventative maintenance, scheduled downtime (e.g., corrective maintenance), system upgrade
- Unplanned field event
 - Lightning, other type of storm, accident (fire), a part failure
- Internal testing

- System is being commissioned or re-commissioned after an upgrade
- Parts of the system are being checked for power

Incident Category Menu Options (must be exact matches in Incident Import Template)

The following menu options are specified for categorizing incidents:

- Hardware failure
 - Any hardware component of the system in the Bill of Materials (BOM) that has failed or stopped working (category includes operational suspensions [out-of-service] resulting from degraded electrical connections)
- Software problem
 - A fault or failure is due to a software error, glitch or incompatibility
 - The root cause is not a hardware failure
 - For example, the inverter went down due to incorrect limits in the code
- Hardware upgrade required to operate
 - Hardware upgrade required based on changes in the electrical code or the utility requirements
 - For example, changes to anti-islanding policy requires new inverters
- Software upgrade required to operate
 - Software upgrade required based on changes in the electrical code or the utility requirements
 - For example, changes to anti-islanding policy
- Equipment installation problem
 - The system is down due to an incorrect installation
 - For example, the modules or inverters were not correctly grounded, the trackers were not aligned correctly
- Grid-induced failure/suspension
 - Any system upset condition caused by a disturbance on the grid to which power is being supplied
- Lightning-induced failure/suspension
- Environment-induced failure/suspension
 - Degraded system condition caused by environmental factors other than lightning (e.g., hail, wind, etc.)
 - Degraded system condition caused by wildlife
 - Degraded system condition caused by array maintenance activities (e.g., grass or weed control)
- Hardware application problem
 - Power loss due to poor design for the application
 - For example, building shading not taken into account;
- Software application problem
- Vandalism
- Unknown
 - The source of the incident is unknown
 - Does not fit into any other category
 - The incident was logged by someone without providing a category
- Hardware upgrade

- A batch of identical components are replaced with upgraded versions prior to failure
- For example, all inverters replaced, new AC disconnects put in based on utility upgrade
- Software upgrade
 - The system or part of the system is down for the manufacturer to install new software
 - For example, tracker controllers, monitoring systems
- Planned maintenance
 - Scheduled maintenance (routine or otherwise) such as cleaning operations, hardware modification or replacement, tracker mechanical maintenance
- Troubleshooting issue
 - A failure or suspension occurs due to the troubleshooting process
 - For example, while changing a fan in an inverter, a capacitor is broken.
- System upgrade
 - A general upgrade to the system
 - For example, another PV array with inverter is added to the existing PV system
- End of useful life failure
 - This failure cannot be repaired but should be documented
 - For example, a transformer is blown due to a voltage surge, a module junction box fails and no power can be extracted

Incident Category Discussion

AC disconnect switch (ADS) blown fuses are not fuse failure events. They are the consequence of some other event. The purpose of a fuse is to interrupt (open) an electrical circuit to prevent damage to other electrical components that could result from an undesirable electrical condition. If an ADS fuse is blown due to another BOM hardware failure (e.g., an inverter part), then the failed BOM hardware should be identified as the responsible BOM part --- not the AC disconnect switch. If, on the other hand, the blown AC disconnect fuse is the result of ADS contact degradation, then the AC disconnect is to be identified as the responsible BOM part.

Likewise, a DC disconnect switch (DDS) interlock fault may often be the consequence of some other event. As with the ADS, the responsible BOM part should be identified as appropriate. If the interlock fault is the result of something other than a BOM hardware failure (e.g., environment-induced), then the DDS is to be identified as the responsible BOM part.

Where the ultimate cause (Incident Category) for an ADS or DDS fault is unknown, then the ADS or DDS will have to be identified as the responsible BOM part. This reasoning is also applied to the BOM part identified as ECON (i.e., PV system electrical cables, connectors, fuses, diodes, etc.) in Figure 3.

Failure Type Menu Options (**must be exact matches in Incident Import Template**)

XFRACAS™ has a data analysis export function for RGA™ and Weibull++™. The former tool can be used for repairable systems analysis, while the latter is used for life data analysis. Weibull++™ requires the assumption that failures are independent of each other. This assumption is not true for repairable systems because only a portion of the repairable system is

restored as opposed to the entire system. Although repairable system analysis can be performed in the recurrent data analysis (RDA) folio of Weibull++™, the XFRACAS export function does not export data to the RDA folio.

In order to obtain correct data exports for Weibull++™ and RGA™ the following Failure Type menu options are specified for BOM hardware inoperability events:

Inverters

- Inverter Inoperable – preventative maintenance
- Inverter Inoperable – corrective maintenance
- Inverter Inoperable – grid-induced
- Inverter Inoperable – lightning-induced
- Inverter Inoperable – other-induced

All other BOM hardware

- Non-inverter Inoperable – preventative maintenance
- Non-inverter Inoperable – corrective maintenance
- Non-inverter Inoperable – grid-induced
- Non-inverter Inoperable – lightning-induced
- Non-inverter Inoperable – other-induced

Classification of Incident Category and Failure Type Menu Options

The following table of chargeable versus non-chargeable menu options for Failure Type and Incident Category has been configured to obtain convenient sorts of exported data for analysis. The table is configured so that failure events for each component in the BOM can be readily exported for life data analysis into Weibull++™. To export data for inverter downtime events (i.e., due to faults within the inverter and resulting in lost kilowatt hours) for RGA™ repairable systems analysis, it is also necessary to identify the corresponding inverter events as system downing events in the Details tab of the incident import template. System downing events are defined to be incidents where the inverter has downtime due to any cause other than inverter planned maintenance, grid-induced outages, and lightning-induced outages. See Sections 7.3 and 6.1 regarding how to identify inverter incidents as system downing events for legacy data and real time data entries, respectively.

In order to get the correct data exported for Weibull++™ and RGA™ analysis the Chargeable and Non-chargeable Incident Category and Failure Type criteria have been specified as shown in the following table.

	Failure Type*	Incident Category
Chargeable	Non-inverter Inoperable – PM Non-inverter Inoperable – CM Non-inverter Inoperable – GI Non-inverter Inoperable – LI Non-inverter Inoperable – OI	Hardware Failure Software Problem Hardware Upgrade Required to Operate Software Upgrade Required to Operate Hardware Application Problem Software Application Problem Hardware Upgrade Software Upgrade Equipment Installation Problem Troubleshooting Issue System Upgrade End of Useful Life Failure Environment-induced Failure/Suspension Vandalism Unknown
Non-chargeable	Inverter Inoperable – PM Inverter Inoperable – CM Inverter Inoperable – GI Inverter Inoperable – LI Inverter Inoperable – OI	Planned Maintenance Grid-induced Failure/Suspension Lightning-induced Failure/Suspension

* PM – preventative maintenance
CM – corrective maintenance (inherent part failure/suspension)
GI – grid-induced failure/suspension
LI – lightning-induced failure/suspension
OI – other-induced failure/suspension

Other Definitions

Reliability – ability of a system, subsystem, or component to perform its required function under stated conditions for a stated period of time

Availability – probability that a system, subsystem, or component will be performing its intended function when required

Commissioning Date – date when system, subsystem, or component first began performing its intended function

kWh Loss – loss of system power output resulting from system equipment failure events or operational suspensions

Service Response Date/Time – date/time of response to system, subsystem, or component failure or out-of-service event

Service Completed Date/Time - date/time system, subsystem, or component functional capability is restored following failure or out-of-service event

Repair Duration – difference between event service response date/time and service completion date/time, to nearest hour (reliability metric)

Restored to Duty Date/Time – date/time system, subsystem, or component is once again performing its intended function following failure or out-of-service event

Down Time – difference between event occurrence date/time (date/time failed or OOS) and restored to duty date/time, in hours (availability metric)

Service Down Time – difference between event occurrence date/time (date/time failed or OOS) and service completed date/time, in hours (reliability metric)

System Hours – cumulative operating hours since system commissioning

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