

Sandia's PV Reliability Program*

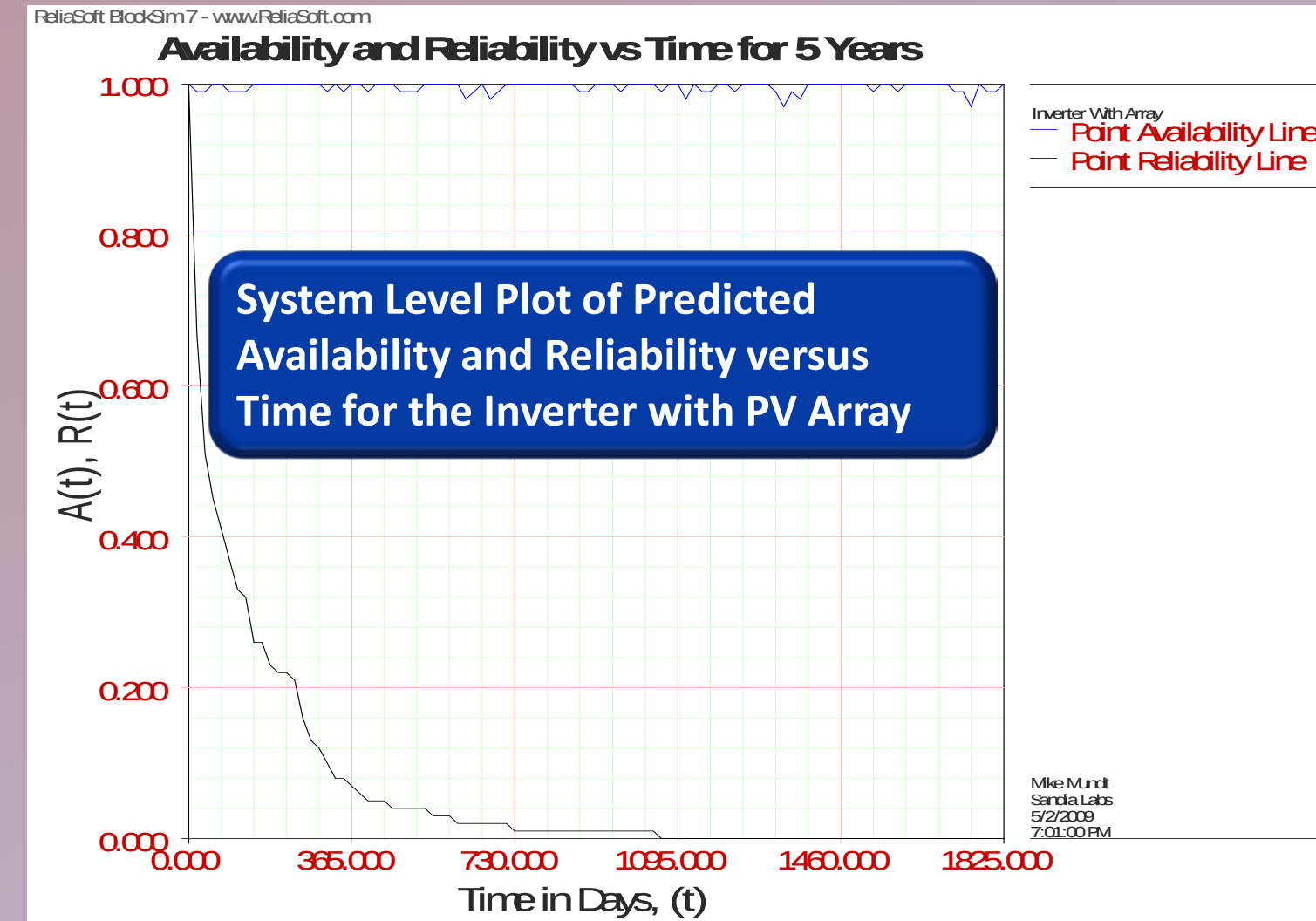
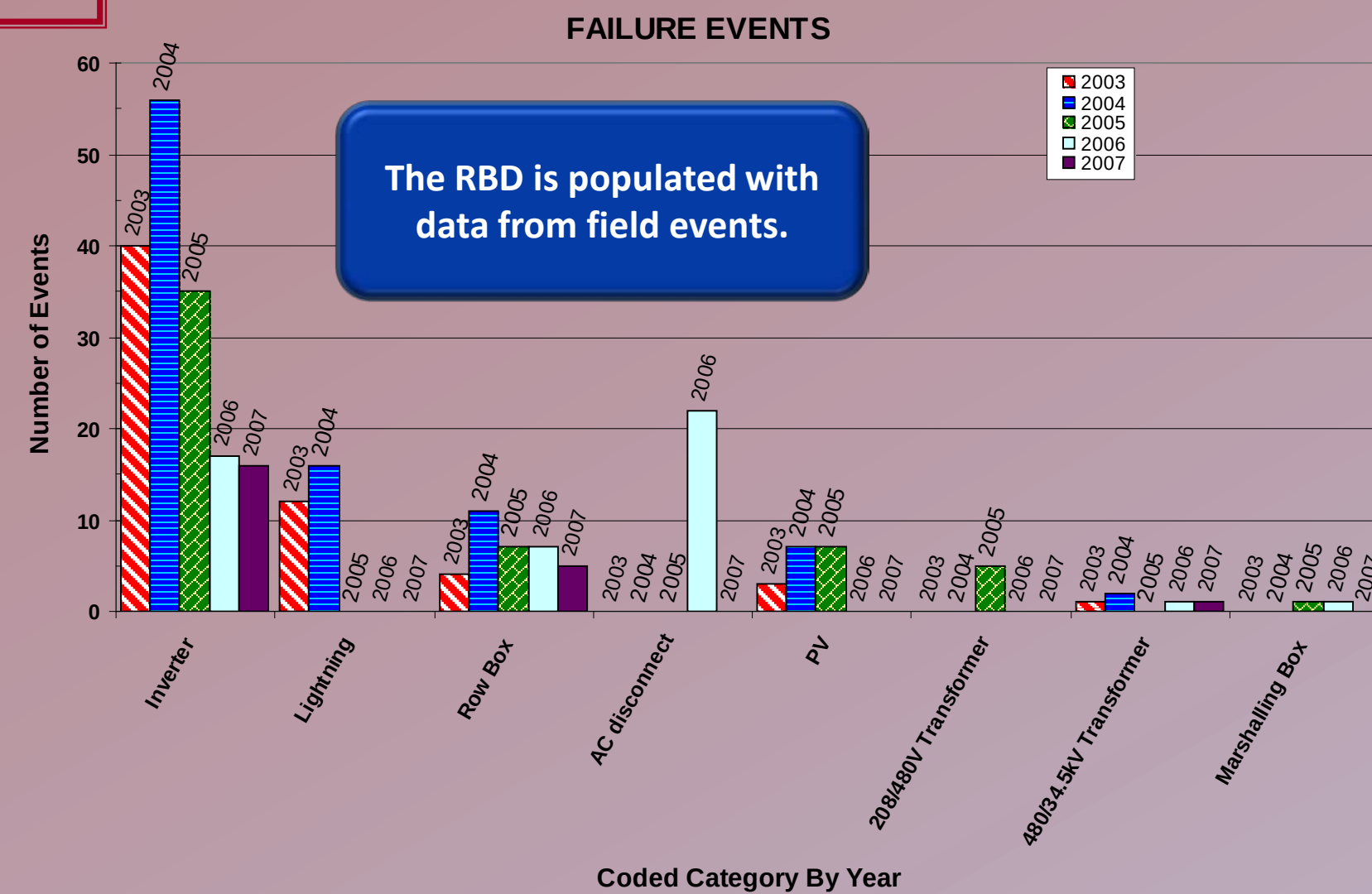
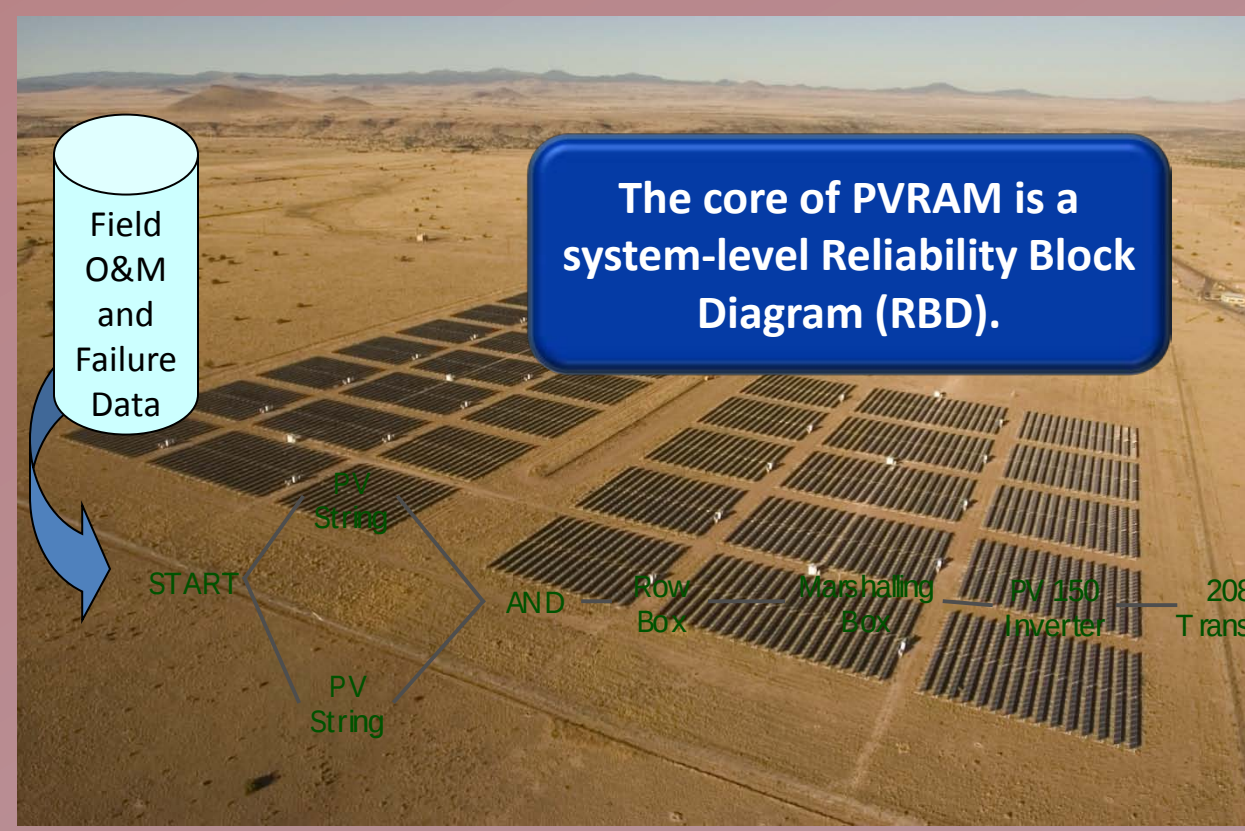
Rob Sorensen, Michael Quintana, Jennifer Granata, Mike Mundt, Jeff Mahn, Elmer Collins, Chad Staiger, Enrico Quintana

Sandia National Laboratories

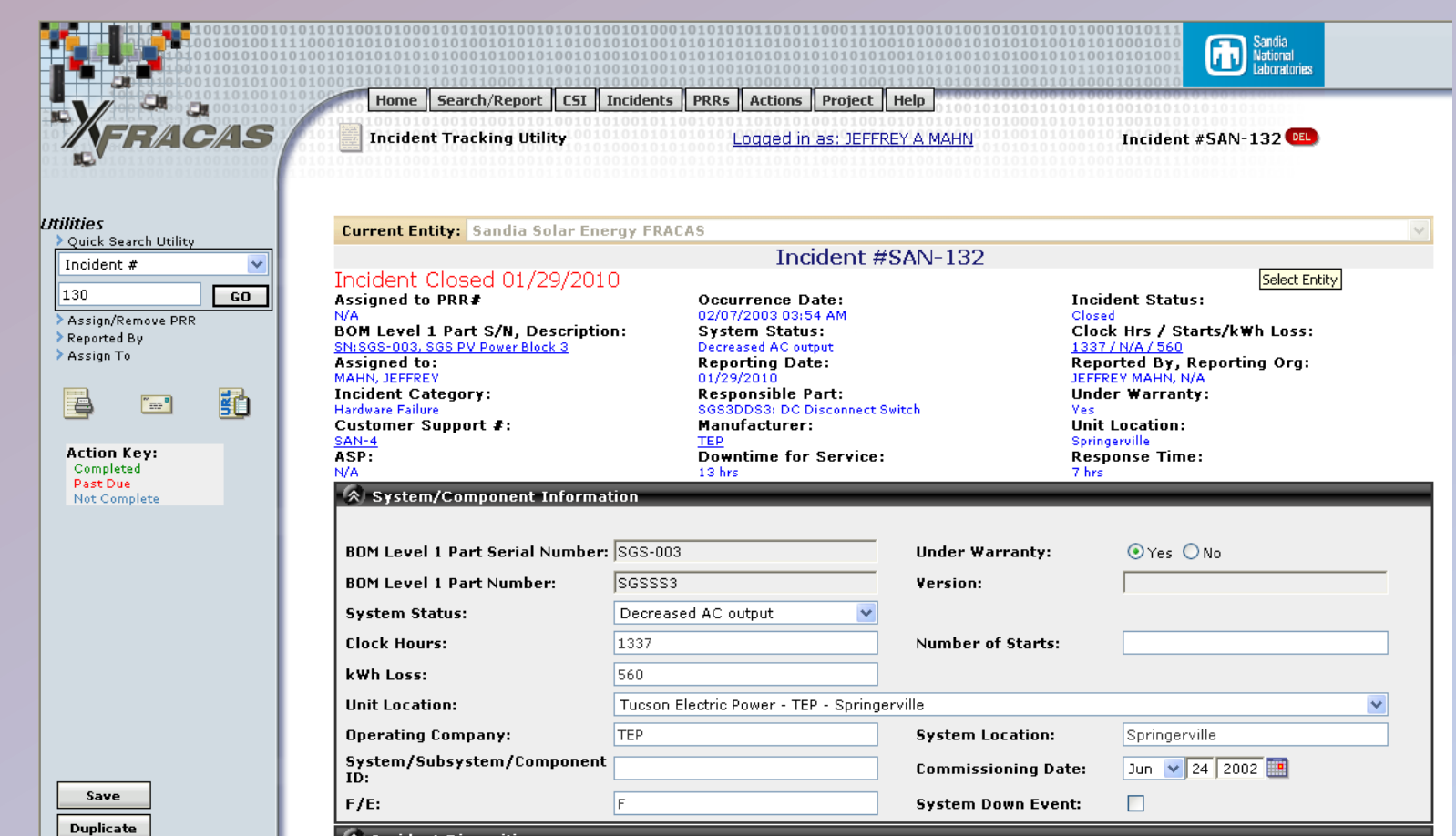
*Sandia & NREL work collaboratively on the DOE Solar Energy Technologies Program PV Reliability Project

Reliability Model (PVRAM & PVROM)

PVRAM Goal: Predict for any component and any level of the system - *degradation* versus time; *reliability* versus time; *availability* versus time



PVROM Goal: Compile failure event data into a web-based database for use with PVRAM

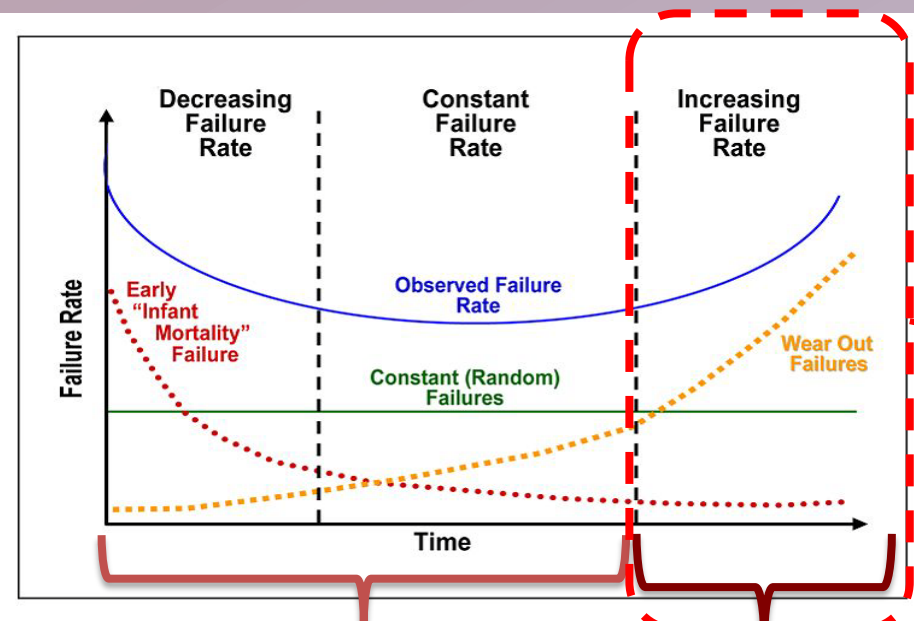


Selected a database tool to be used as a repository for field data: XFRACAS (Failure Reporting, Analysis, and Corrective Action System)

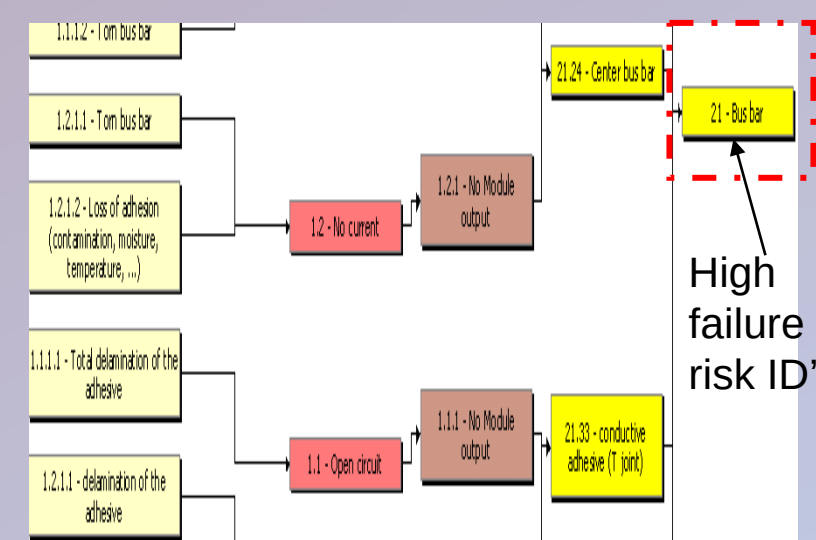
- Supports acquisition, management and analysis of system quality and reliability data from multiple sources
- Creates a standardized method for collecting and maintaining O&M data
- Web-based: easy access for all users
- Security:
 - Password-protected
 - Single administrator determines individual user's access to every area of the database
 - Customer-specific data will be made available to data owner only
 - Aggregate data analysis will be made available through Public Reports
- Supports both real-time and legacy failure/suspension data acquisition
 - Legacy data imported into database via Excel template
 - Real-time incident records created via Incident Wizard and incident Tracking Utility
- Supports incident record searches and report generation
- Data can be directly exported to predictive model tools for analysis

Accelerated and Diagnostic Testing

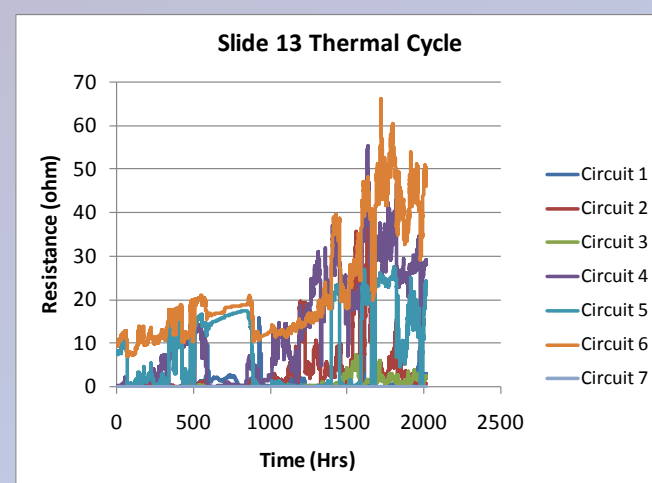
Field data do not provide wear out (end-of-life) information



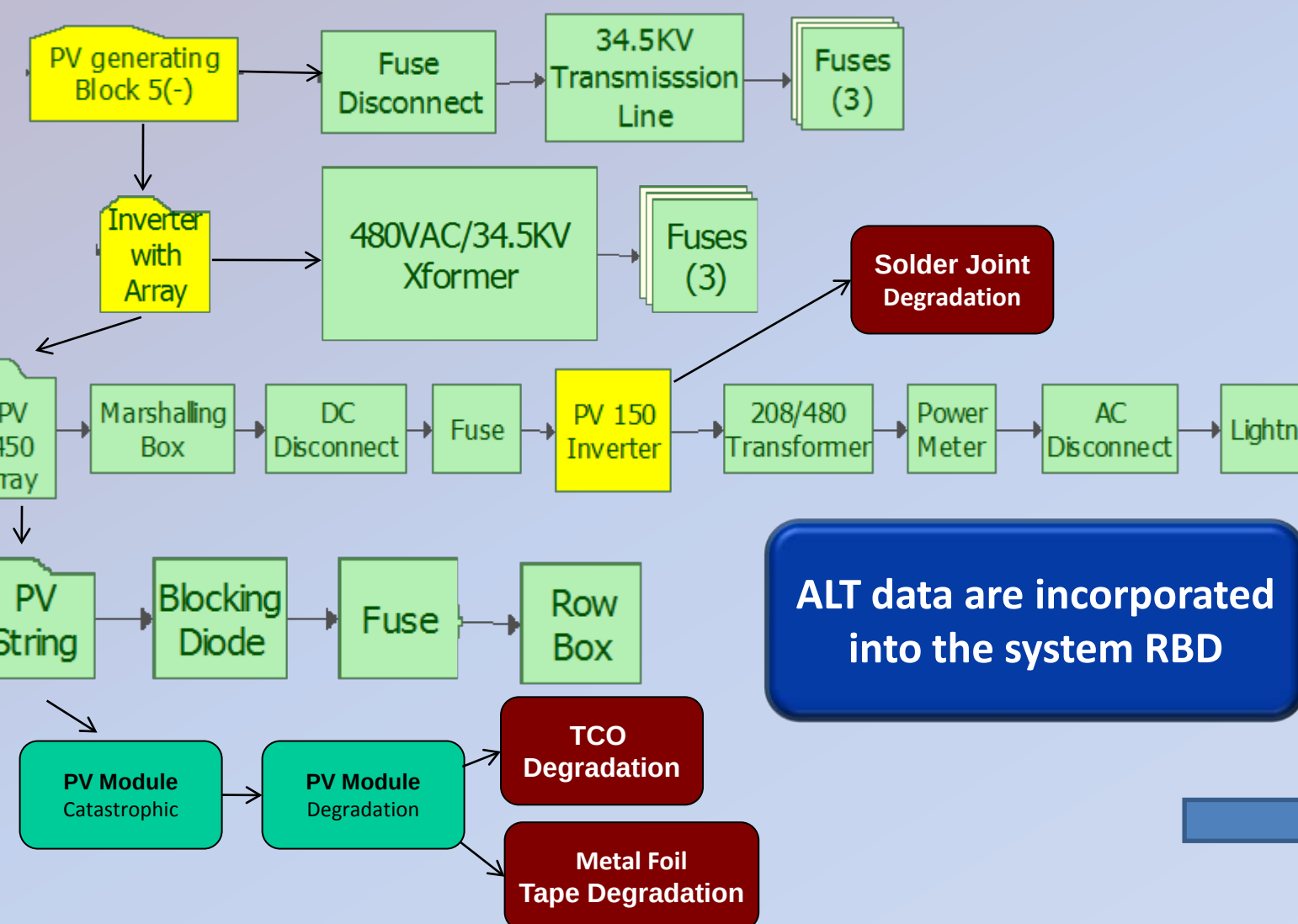
Failure Modes and Effects Analysis Identifies Reliability Concerns (Metal Foil Tape)



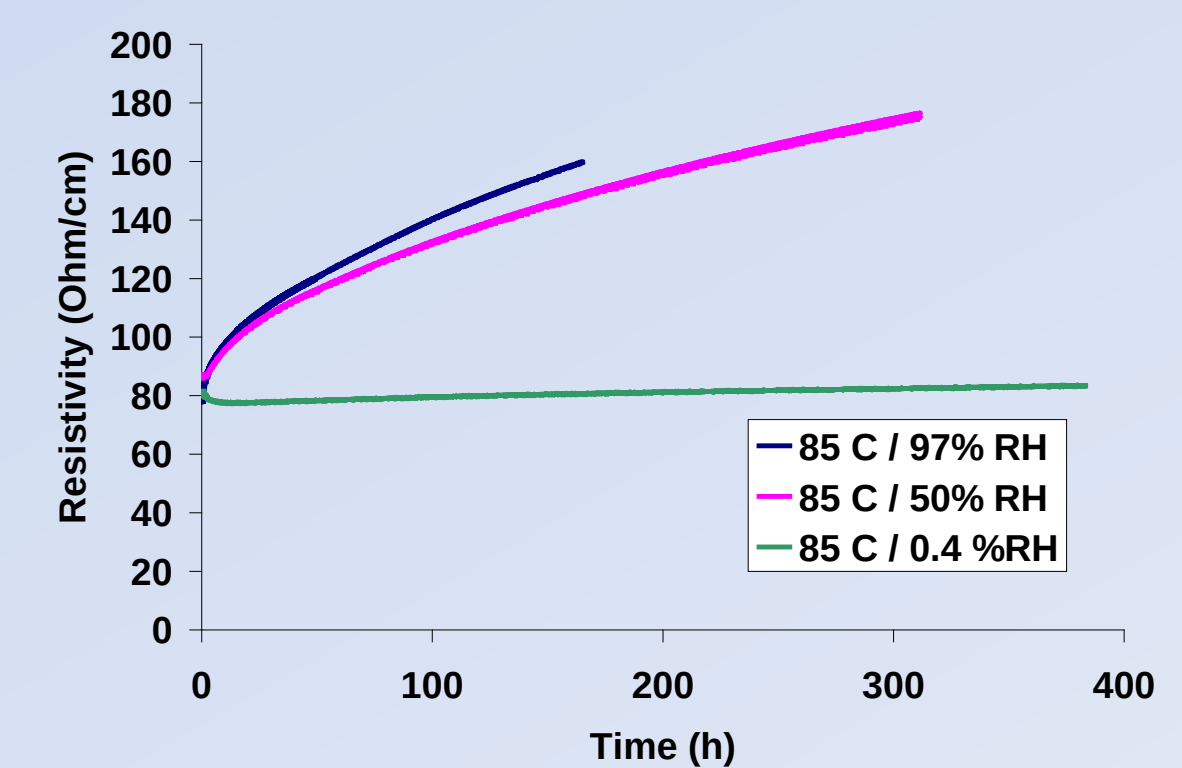
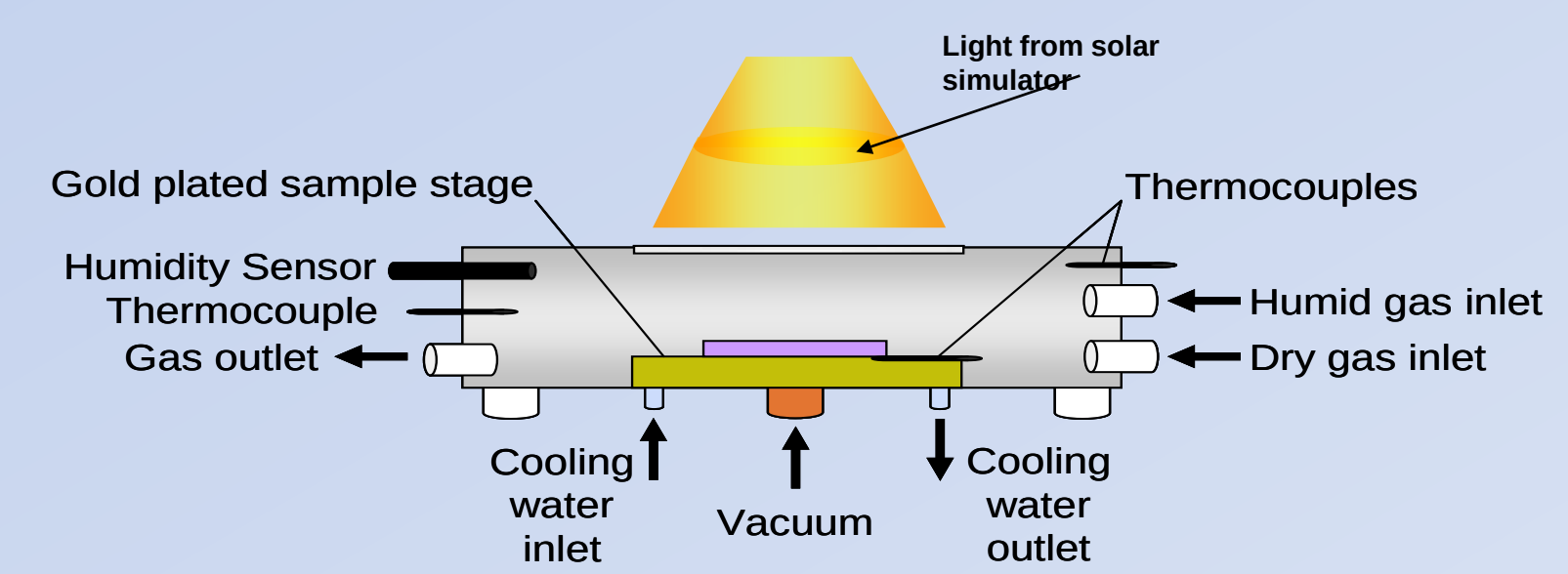
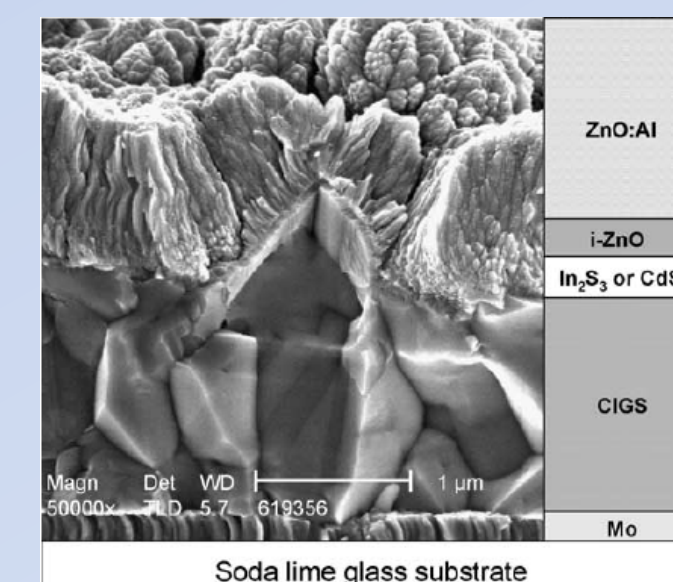
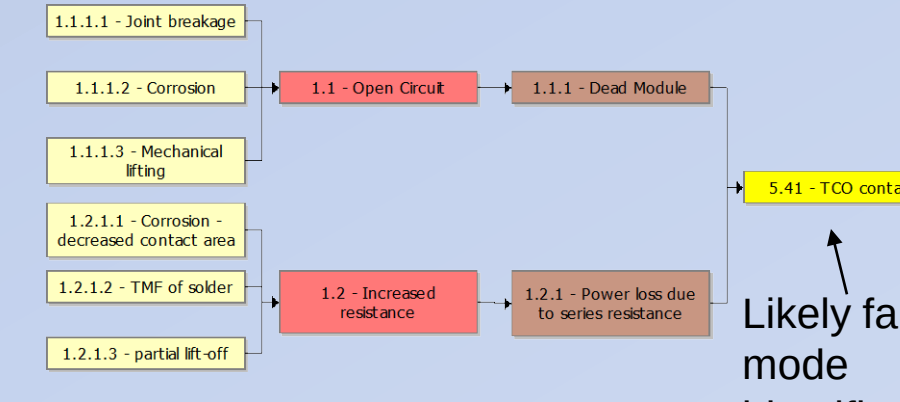
ALT Data Generated in Lab Tests



ALT Results Map to System Performance



FMEA for CIGS: TCO is high level reliability concern



Humidity (%RH)	Temperatures (°C)	Irradiation (Suns)	TCO
85	85, 50, 30	0.1	AZO ¹ , i-ZO/AZO ²
50	85, 50, 30	0.1	AZO, i-ZO/AZO
25	85, 50, 30	0.1	AZO, i-ZO/AZO
0	85, 50, 30	0.1	AZO, i-ZO/AZO

Real Time Reliability Studies

System-Level Real Time Reliability Studies

- System Long-term Exposure of 13, 1-kW grid-tied systems in 3 environments (5 manufacturers)
- Controlled study includes baseline testing (Dark IV, IR, outdoor electrical performance)
- Hot/Dry, Hot/Humid, and Cold environments
- Performance monitoring; Quarterly and Semi-annual testing
- At ~5 years use field degradation rates and failure modes to correlate/validate ALT results, feedback to stakeholders, and input to predictive model development

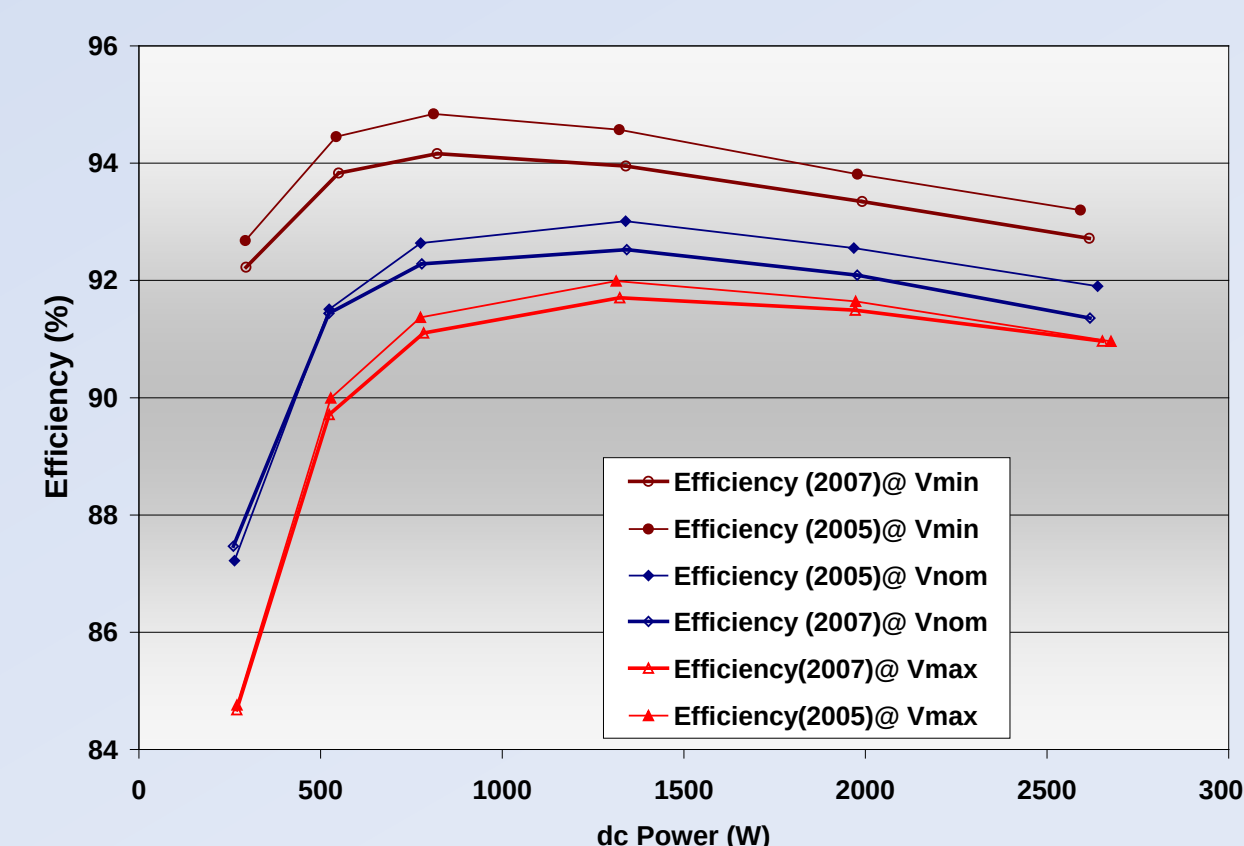
GSA System Reliability Monitoring and O&M Data Collection

- Monitor systems to collect reliability data: failure modes, O&M, and performance
- Mostly roof mount, many in diffuse climates, variable size systems, some will use emerging technologies

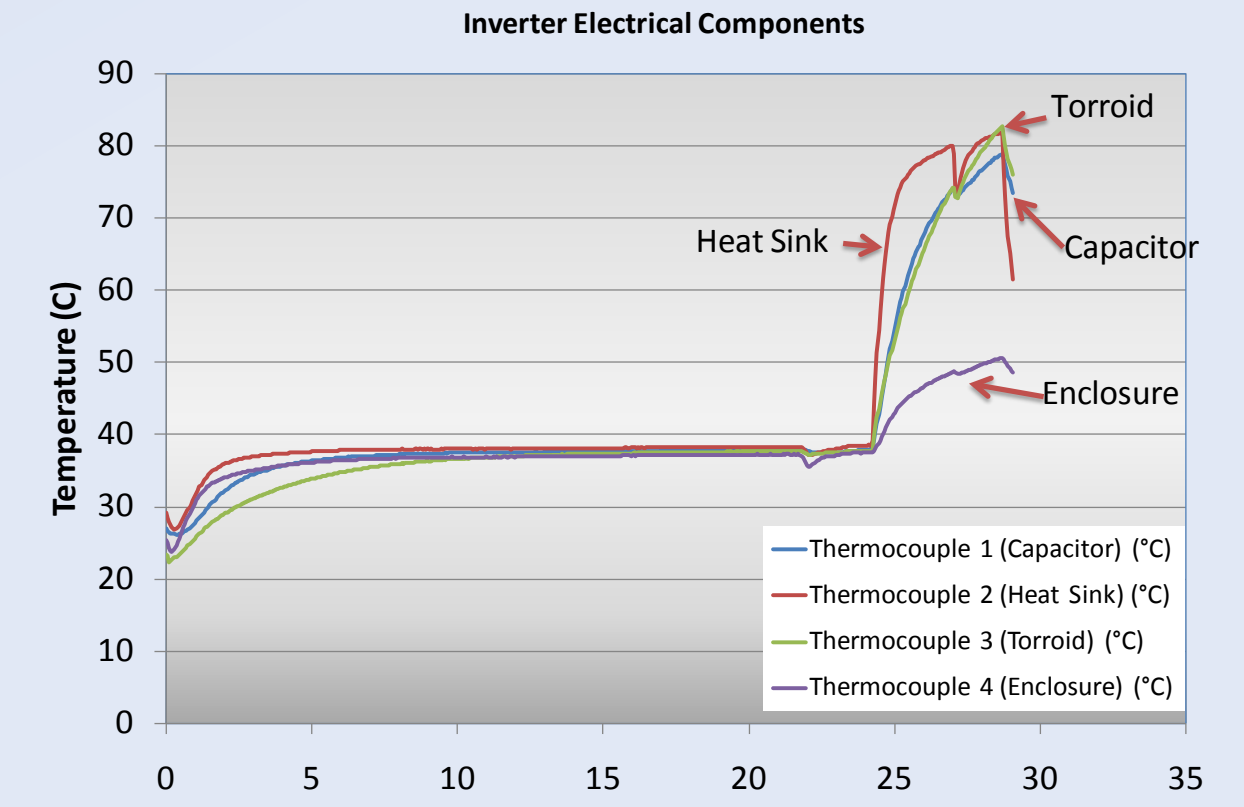
Inverter Long-Term Exposure

- Hot/dry and Hot/humid long term degradation studies
- Inverter high-risk component temperature monitoring studies in hot/dry and hot/humid climates
- Temperature data will be used to develop ALT's for high risk components
- emerging technologies

Inverter Characterization (2005 vs. 2007)



Thermal Profile for Inverter Electronics

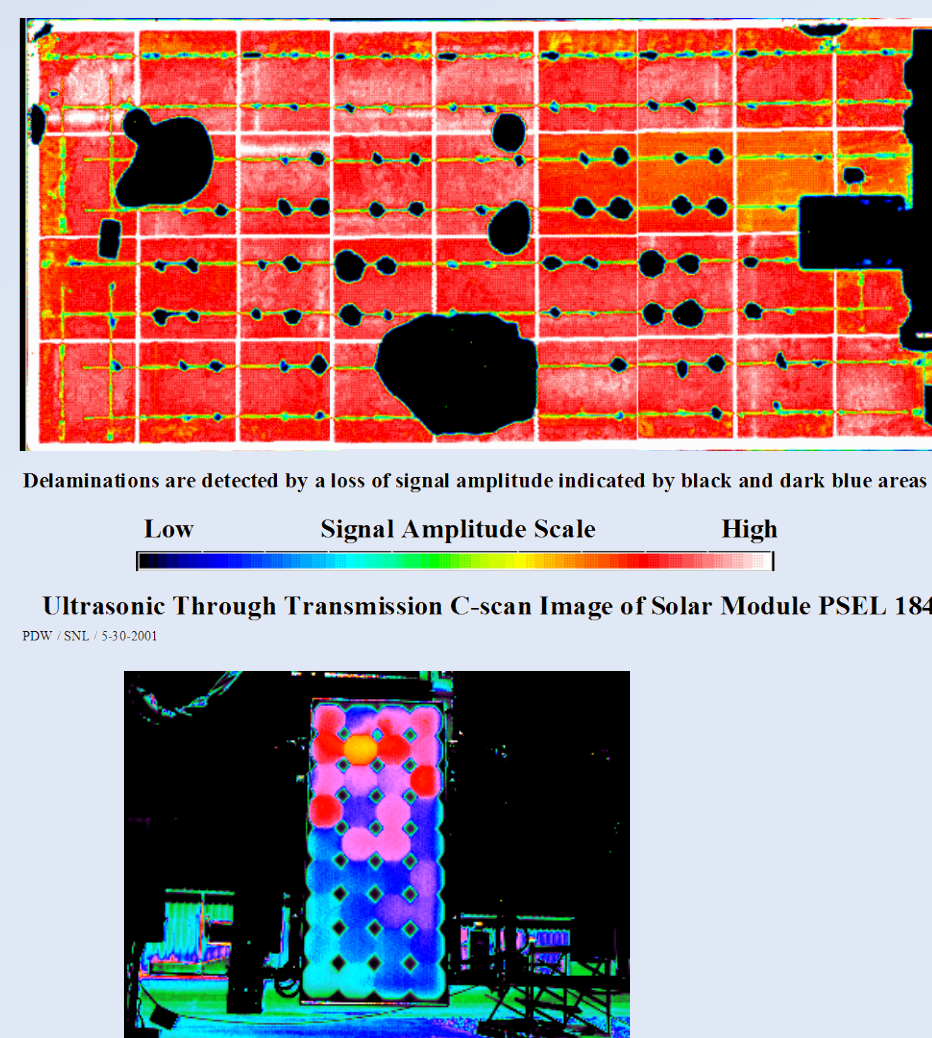
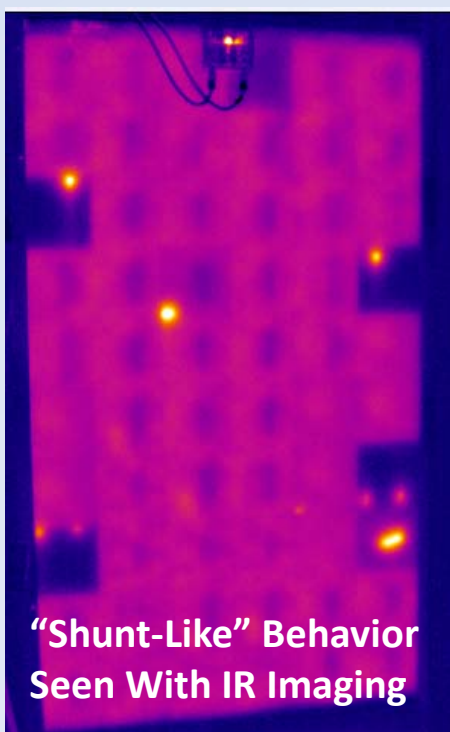
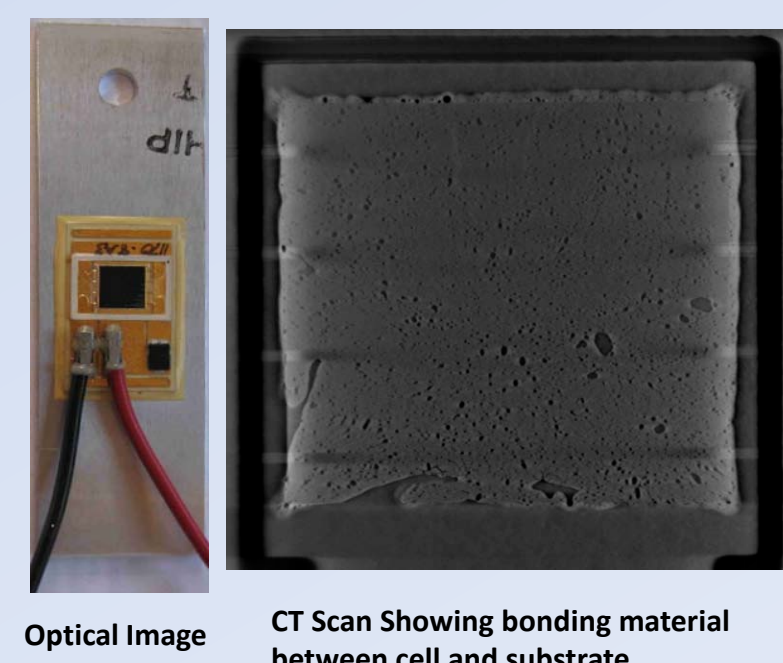


Industry Outreach and Standards Support

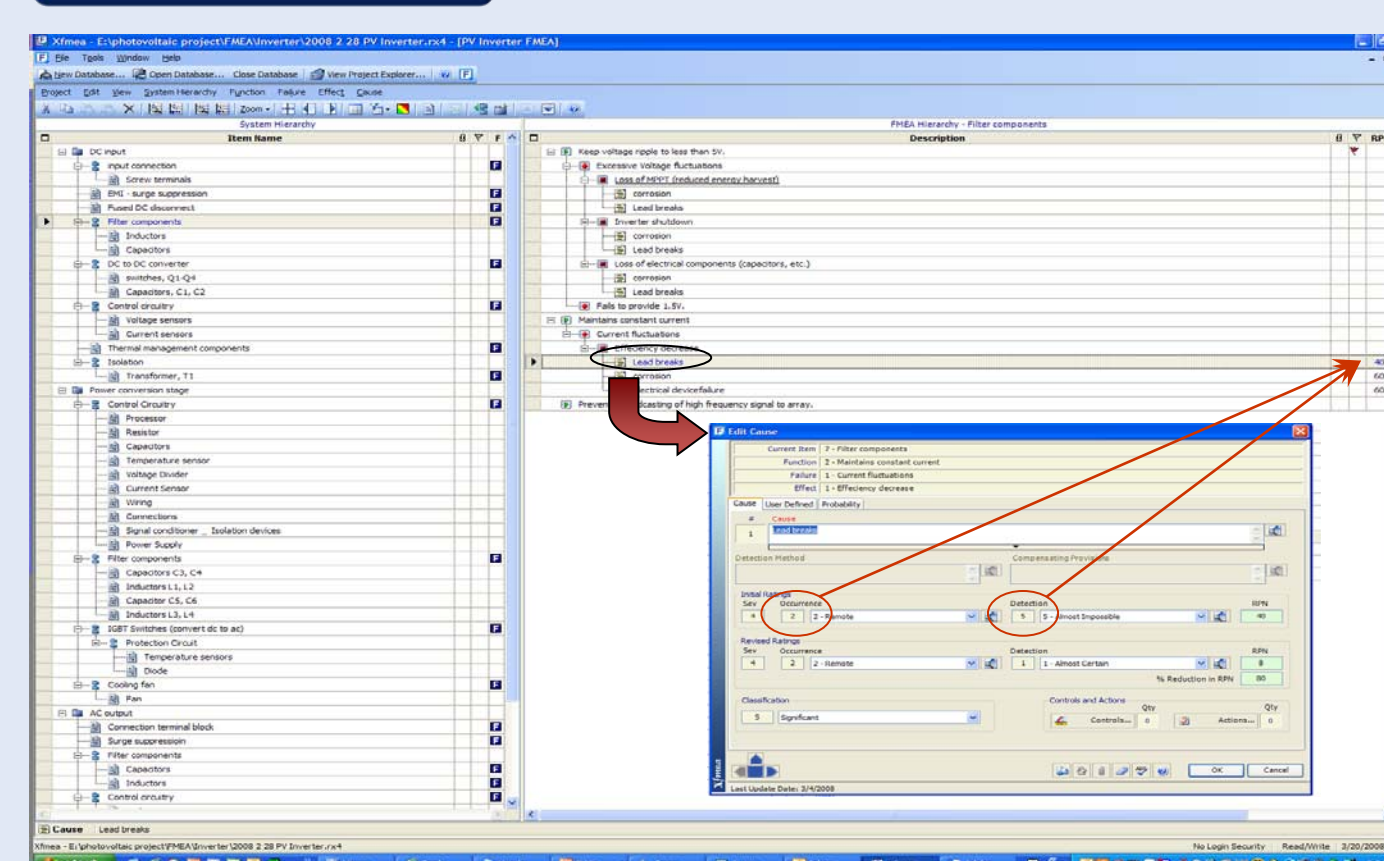
Integrator Reliability Workshop

- March 31- April 1, 2010 San Jose, CA
- Focus on reliability issues specific to integrators
- The goal of this workshop is to examine the roles of the PV integrator portion of the supply chain, understand the reliability implications for installed systems, and define opportunities to enhance how reliability is addressed by integrators. Ultimately, this understanding can advance the industry-wide goal of making photovoltaics a significant part of the U.S. electricity generation portfolio.

Diagnostics



FMEA



Publications

Granata et al., Long-Term Performance and Reliability Assessment of 8 PV Arrays at Sandia National Laboratories, 34th IEEE PVSC
Mundt et al., Reliability and Availability Analysis of a Fielded Photovoltaic System, presented at June 2009 International Applied Reliability Symposium
Collins et al., Reliability and Availability Analysis of a Fielded Photovoltaic System, 34th IEEE PVSC
Sorensen et al., The Effect of Metal Foil Tape Degradation on the Long Term Reliability of PV Modules, 34th IEEE PVSC and 2009 SPIE
Quintana et al., Exploring Diagnostic Capabilities for Applications to New Photovoltaic Technologies, 34th IEEE PVSC
Granata, et al., "Approaches to Photovoltaic Systems Reliability," International Symposium on Testing and Failure Analysis 2009