Developing Codes and Standard for PV

Las Vegas, NV Sept 16, 2016

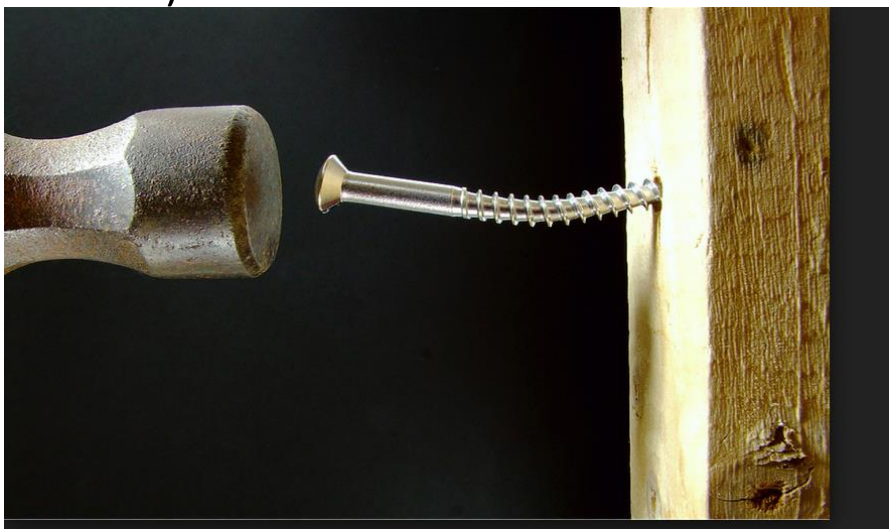
Transition from new conceptual designs into marketable products

- Many new fantastic innovative product ideas.
- Most of these new products will need to comply with building codes before they can be accepted for general use in the US or Canada.
- Too often these new and innovative products do not neatly fit into existing codes, standards and certification categories.
- UL works with industry to develop new codes and standards to facilitate getting new technologies certified and accepted in the field. This effort takes significant investment and time.

Certification for the Purpose

- NEC moving toward equipment certified for the purpose.
- Field failures related to incorrect applications for equipment.
  - Reprogrammed motor drives used a utility interactive inverters
  - UPS used as dynamic Var compensator
  - Industrial control equipment used for power generation applications
    - Electrical Spacings (Creepage and clearances)
      - Overvoltage category
      - Pollution degree
    - Operating temp range
    - Environmental ratings
    - Electrical ratings and markings

  for the application and sources



Coordination of System Equipment

- **System components need to operate safely under normal and foreseeable abnormal system conditions**
- **Differentiate between system faults to which equipment need to respond to vs single fault failures within a piece of equipment**
- **Interaction between energy sources and power conversion equipment**
- **Operation ranges of system equipment**
- **Protection from system faults**
- **Source parameters**

Standards Need Regular Revisions to Keep Pace with Rapid Growth Industries

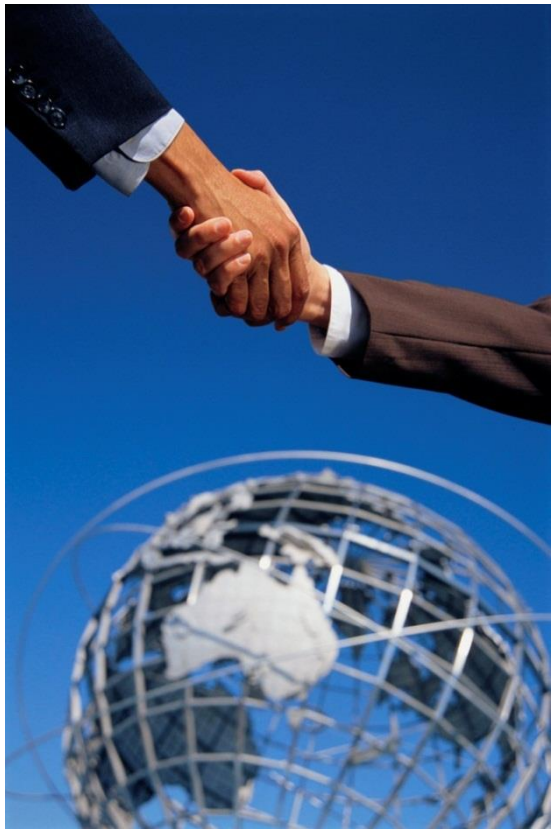
- Standards and codes in renewable energy areas are attempting to process revisions and new requirements more rapidly to keep up with technology innovations.

- Partner with industry, National labs and industry experts to develop, validate and write new standards and codes to support new technologies.

UL Energy Partnerships

•To address the needs of national and international energy stakeholders, UL works closely with;

- Manufacturers
- Regulators
- Government agencies
- Industry experts
- Test labs
- Other certification agencies
- Other standards and code writing agencies



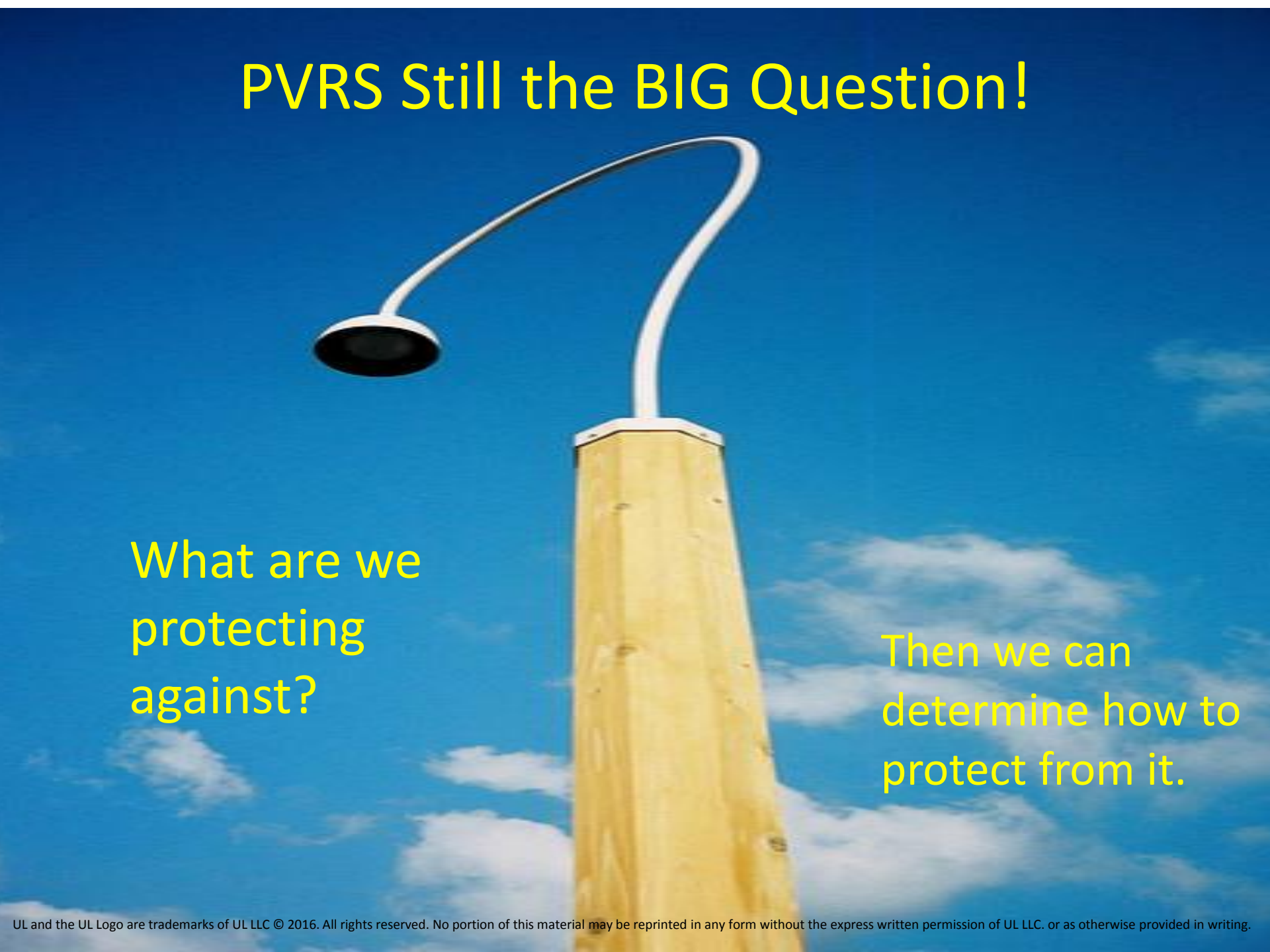
UL's relationships and partnerships with key Energy industry stakeholders is a foundation upon which we write relevant safety and performance standards for cutting edge products and systems.

UL Participation in International Energy Standards for Safety and Performance

•UL is an active member in IEC, International Electrotechnical Commission. UL participates in all of the energy related Technical Committees and provides UL standards and Subject documents as draft material for the development of IEC standards.

TC82 Photovoltaics
TC 69 EV Charging Equip
TC 23 EV Connectors
TC105 Fuel Cells
TC 21, TC69 Batteries
TC88 Wind Turbines

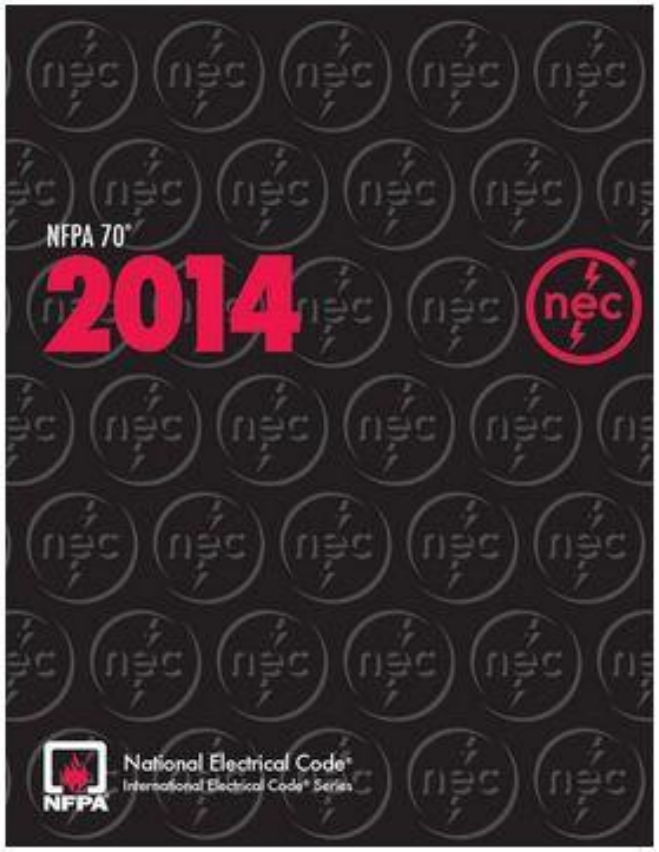
PVRS Still the BIG Question!



What are we protecting against?

Then we can determine how to protect from it.

Wrapping up UL1741 Work to Address 2014 NEC 690.12



Task Group Revising the UL CRD/ UL1741 SPT Draft Proposal for PVRS Equipment and Systems for 2014 NEC

- **Protection of Emergency Personnel**
- **Status Indicators, Initiators and Reset Devices**
- **PVRSS that Includes PV Disconnect Functionality**
- **Operational Tests for PVRSS Verification of levels – Controlled Conductors.**
- **Verification Testing of PVRSS at Rated Extremes**
- **Power Supply Ride Through**
- **Inverters Certified as PVRSE**
- **PVRSS and PVRSE Functional Safety Using Solid State Controls**
- **Functional Safety Standards**
- **Conditions to be Addressed for a PVRSS/PVRSE**
- **Functional Safety Evaluation For PVRSS/PVRSE Using Solid State Controls**
- **Environmental Stress Testing (based on UL991)***
- **Ratings, Markings and Instructions.**

Larry Sherwood
Task Group Leader
“Chief Cat Herder”

UL 1741 STP Timeline to Publish Requirements to Address 2014 NEC PV RSS Requirements

– The draft is being finalized by the end of this year.

– 45 days STP comment period on revised draft.

~ 30 days Task group review of STP comments. Make revisions and changes as task group deems necessary.

– 45 days STP Ballot on revised draft

– ~ 30 days task group review and respond to STP comments and that may include revisions.

- Recirculate draft comment responses Minimum 2/3 Affirmative to reach consensus.

If all goes well we will be able to publish in Q4 2016.

The Path from Golden to Vegas

- We have 3 Ds!

  Destination
  Direction and
  Deadline

Trying not to reinvent the wheel.

- New science based research
  - Sandia and UL
- Gather critical information
  - Fire fighter community
  - PV industry
- Functional safety
  - Researching other potentially related existing standards
  - System level evaluations is related yet very different from equipment level evaluations.
  - *Example Medical – various levels of protection from known hazards for the specific situation with multiple levels of active and passive protection. X-ray machine vs Defibrillator vs Thermometer .*

Goals for New PV RSA Standard

- Develop standard/requirements for PV array RS systems that is:
  - Array /system based (not single solution focused)
  - Science-based
  - Written to address specific defined hazards and safety concerns for fire fighters.
  - Written to define specific normal and abnormal conditions of use.
  - Written to be implementation agnostic so as to allow for a range of product designs, concepts and innovations.
  - Voltage is a real concern, but more importantly is that this document identifies a way to keep the fire fighter out of a hazardous current path.

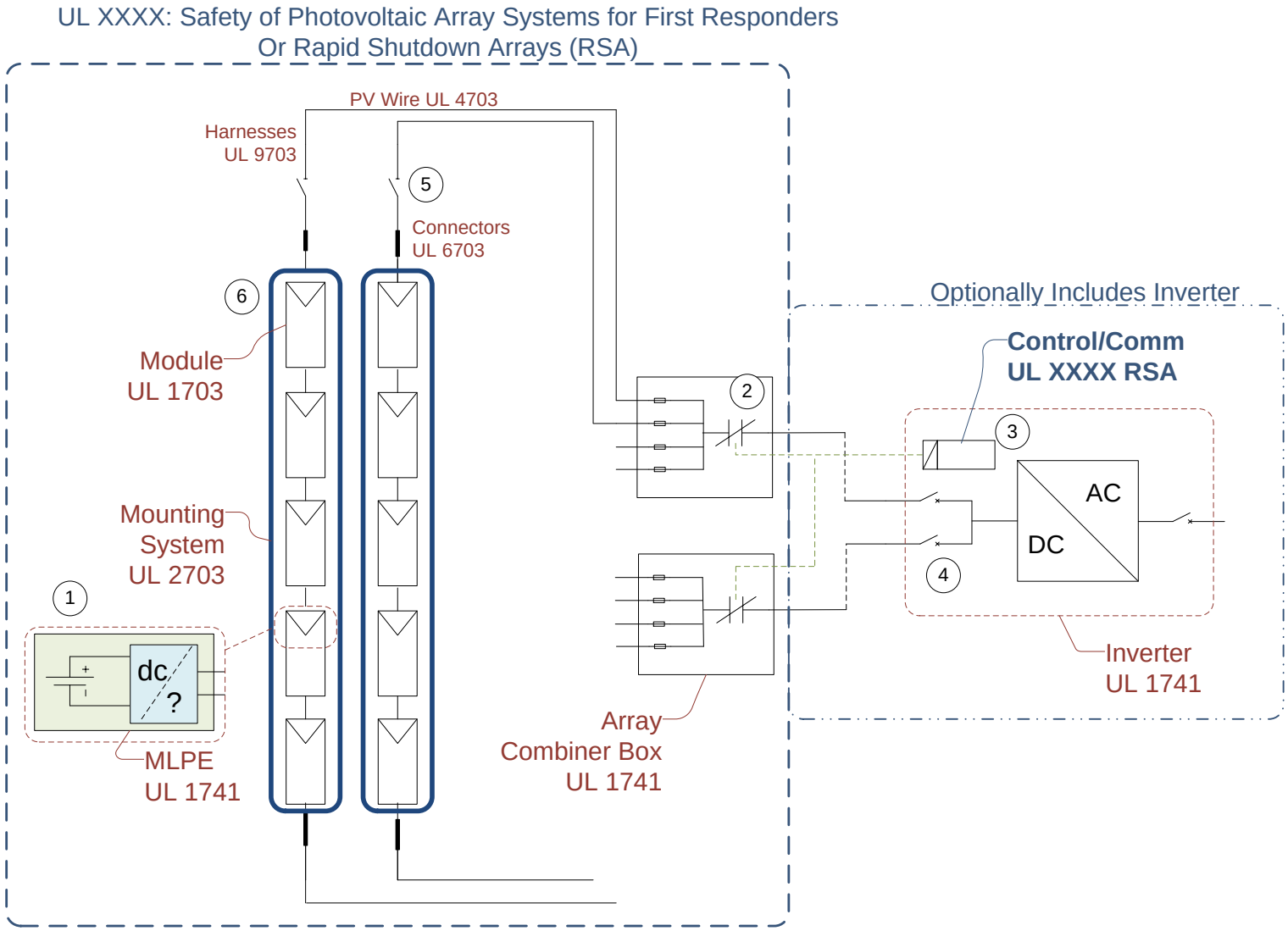
UL to develop new STP for PV rapid shutdown systems.

PV module mfrs (UL1703)
Electronics (UL1741)
PV rack mfrs (UL2703)
Harness mfrs (UL9703)
PV wire, connector and harnesses (9703, 6703,etc)

Fire Fighting Community
AHJs
Functional safety and risk assessment experts
National labs
Industry experts
Others

UL 14713071? – System level standard

Rapid Shutdown Array Standard Functional Diagram



Functional Safety

- Levels of protection including both active and Passive Safeguards
- This methodology will allow a means to address the many “What If” scenarios that could happen in the real world that are unlikely to all happen concurrently.

RS Standard – Proposed Functional Requirements

- Evaluate equipment and means for providing a reduced level of hazard inside the boundary of a PV array.
  - Limit hazardous body current by:
    - Limited access to live parts
    - Reduce voltage of live parts
    - Limit current through body
    - Combinations of above.
- Specify array damage conditions for which shock hazards must be evaluated.
- Establish an acceptance criteria for damaged systems using risk-based hazard assessment
  - Understanding that hazard elimination is not possible
  - Using established methods from other industries

Risk Based Hazard Mitigation Probabilities and Severity

- Criteria for protection depend on probabilities of hazard and harm.
- Yellow areas are the challenge for this standard
- Real world system failure data helpful for validation
- IEC 61508 defines approaches when actual data not available

			Potential Consequences				
			L6	L5	L4	L3	L2
			Minor injuries or discomfort. No medical treatment or measureable physical effects.	Injuries or illness requiring medical treatment. Temporary impairment.	Injuries or illness requiring hospital admission.	Injury or illness resulting in permanent impairment.	Fatality
			Not Significant	**Minor**	**Moderate**	**Major**	**Severe**
Likelihood	Expected to occur regularly under normal circumstances	**Almost Certain**	**Medium**	**High**	**Very High**	**Very High**	**Very High**
	Expected to occur at some time	**Likely**	**Medium**	**High**	**High**	**Very High**	**Very High**
	May occur at some time	**Possible**	**Low**	**Medium**	**High**	**High**	**Very High**
	Not likely to occur in normal circumstances	**Unlikely**	**Low**	**Low**	**Medium**	**Medium**	**High**
	Could happen, but probably never will	**Rare**	**Low**	**Low**	**Low**	**Low**	**Medium**

Developing the Standard

- Establish method of characterizing tolerable level of electrical hazard risk to comply with NEC article 690.12 (2017).
- Specify requirements for undamaged and single point of failure conditions
- Specify array damage conditions for which shock hazards must be evaluated.
- Define compliance criteria / limits based upon appropriate impedance models of personnel in the context of firefighter operations (body impedance, clothing and gear, tools, etc.)
- Specify tests designed to simulate inadvertent contact with array components by firefighter personnel, based on typical firefighter rooftop operations and associated scenarios for accidental contact.
- Establish a functional safety scoring system

Research Needed

- Testing to inform impedance models of firefighters in typical gear and electrically
- Relevant environment, rooftop, ground paths, gear, water, etc.
- Testing to inform shock hazard of circuits of different voltages without ground
- References, with varying numbers of parallel connected strings, etc.
- FF tactics and risk scenarios developed from previous dialog and research
- Experiments to develop tests that will simulate shock scenarios, such as:
  - Body with gear and falling on array/modules
  - Accidental contact of components with foot/hand/tools etc.

New DOE Research Sandia and UL

Expansion on original UL Fire Research

- 1. Evaluate different configurations of PV
- 2. Define safe states for PV systems operation under emergency conditions
- 3. Determine risk of electrical shock in ungrounded, isolated PV arrays
- 4. Evaluate electrical enclosure protection from firefighting liquids
- 5. Harmonize safety standards and committee work

We Need a New Name for PVRS

- PVRS is not rapid nor is it shutdown.
- Possible good words to describe the attributes
  - Isolation
  - Protection
  - Array
  - Fire Fighter

- Some new ideas
  - Fire Fighter Array Protection -FFAP
  - PV Protection System - PVPS
  - Fire Fighter PV Protection System - FFPPS

Thank you

Tim Zgonena
Principal Engineer
UL LLC

Visit us at http://www.ul.com