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Background Materials

- Protection System Misoperations Task Force Report
- Protection System Misoperations Dashboard
- NERC Misoperation Reporting Template
- Questions and Answers for NERC Misoperations Reporting

Questions and Answers from Webinar (1)

- Is the 'Incorrect Protection Setting' category (1) a calculation error, (2) an incorrect transmittal of a setting to the field, (3) an incorrect placement of a setting on the protective device in the field or a combination of all these factors?
  - Incorrect settings are not due solely these factors, and they also include errors in impedances, fault models and element application.
  - Incorrect placement of a setting in the field should be cause coded as "as-left personnel error".
- In Rich Bauer's presentation - where did he get the "thru 4/13" data from? We haven't had to submit our data to SERC yet?
  - The misoperations from Mr. Rich Bauer's presentation are reported from NERC Event Analysis data. Event Analysis data is separate from the PRC-004 reporting to the Regional Entities and is reported within 10 days of a disturbance event.
- Setting errors appear to stem from a training/experience issue. Are you expecting each entity to address this individually? Seems like a NERC series of workshops would be beneficial.
  - A training module to address specific protection system issues is being considered to help address the problem NERC-wide. Individual entities should also address relevant issues internal to their company.

Questions and Answers from Webinar (2)

- To what level of review are the relay settings peer reviews taken?
  - "The review generally consists of verifying that the relay scheme is wired according to the design drawings, uses the correct potential and current transformer ratios, and checks the input/output connections for used for tripping and control. Once the relay application is reviewed, then the protection setting calculations are checked for correct application and mathematics."
  - Processes, Issues, Trends and Quality Control of Relay Settings, IEEE PSRC System Protection Subcommittee Working Group C3, http://www.pes-psrc.org/Reports/Processes_Issues_Trends_and_Quality_Control_of_Relay_Settings.pdf, pp. 14-15.
- For misoperations resulting from the application of functionally different relay elements, was this primarily due to the sophistication of new microprocessor protective devices (many element types) or due to attempting to coordinate new microprocessor protective devices with existing legacy electromechanical relays?
  - The misoperations resulting from the application of functionally different relay elements were primarily due to attempting to coordinate new microprocessor devices with electromechanical relays.

Questions and Answers from Webinar (3)

- Can you elaborate on the 24 hour bullet point from the last slide (slide 48)?
  - Currently, multiple misoperations are reported if a multiple trips occur before a field technician can troubleshoot the relay.
  - Having a 24-hour window where the trips are considered one misoperation would help to consolidate multiple occurrences, that are essentially the same equipment, into the same corrective action plan.
  - Instead of creating separate misoperations, the number of trips would be recorded for these misoperations.
- Are there any plans to mandate through the adoption of new reliability standards specific corrective actions relating to human performance (i.e. peer review of settings)?
  - At this time, there are no plans to adopt new reliability standards to mandate specific actions relating to human performance.

Questions and Answers from Webinar (4)

- As far Microprocessor based relays, did you have any specific model that you recommend?
  - Based on the NERC anti-trust guidelines, no specific model of relays can be recommended. However, the majority of the misoperations were related to the application of the relay rather than the attributes of a particular model.
- Was there an overall sense that utilities were not coordinating with each other well?
  - Based on the analysis of the data, it could not be definitively determined that utilities were not coordinating well with each other. However, entities should strive to improve their coordination efforts amongst their neighboring entities to improve protection system reliability.

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Protection System Misoperations Task Force

Targeted and Actionable Steps to Reduce Protection System Misoperations

May 7, 2013

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Anti-Trust Guidelines

- It is NERC's policy and practice to obey the antitrust laws and to avoid all conduct that unreasonably restrains competition.
- This policy requires the avoidance of any conduct that violates, or that might appear to violate, the antitrust laws.
- Among other things, the antitrust laws forbid any agreement between or among competitors regarding prices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that unreasonably restrains competition.

Public Meeting Notice

- Participants are reminded that this webinar is public.
- The access number was posted on the NERC website and widely distributed.
- Speakers on the call should keep in mind that the listening audience may include members of the press and representatives of various governmental authorities, in addition to the expected participation by industry stakeholders.

Agenda

- Objectives
  - Jeff Mitchell, NERC Planning Committee Chair, Director, Reliability Assessment and Performance Analysis, Reliability*First* Corporation
- NERC Event Analysis Trends in Protection System Misoperations
  - Rich Bauer, Senior Reliability Specialist, NERC
- Protection System Misoperations Task Force Report Key Findings
  - Andy Slone, NERC, Reliability Performance Analysis Engineer
  - Richard Quest, MRO, Principal Systems Protection Engineer

Objectives

- Provide insight into protection system misoperations
  - Identified as a significant reliability issue
- Lessen the disturbance event severity caused by misoperations
- Disseminate actionable information to prevent and reduce misoperations

2012 Event Analysis Misoperation Data

Event Misoperation Trends

Rich Bauer, NERC, Senior Reliability Specialist
May 7, 2013

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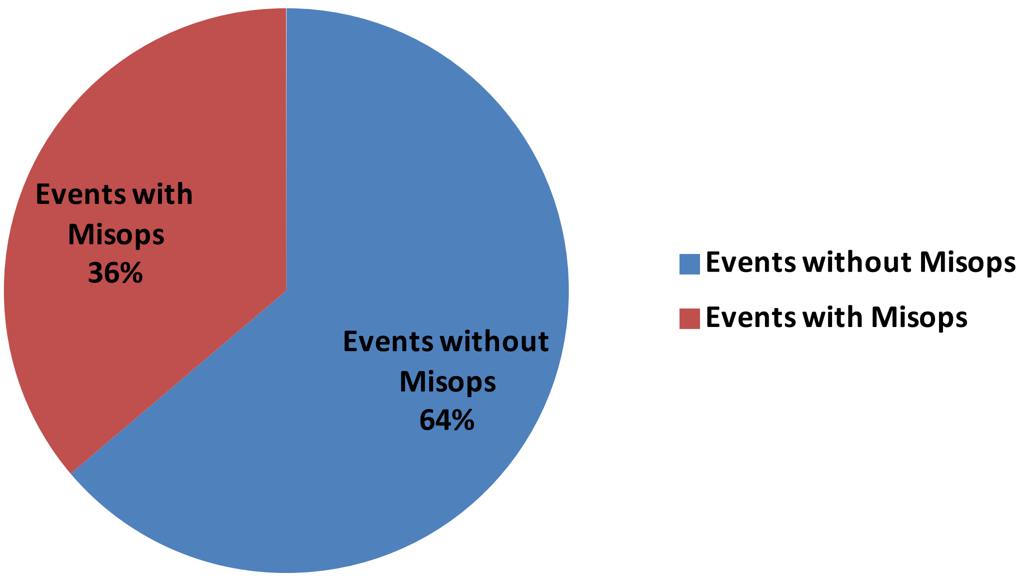
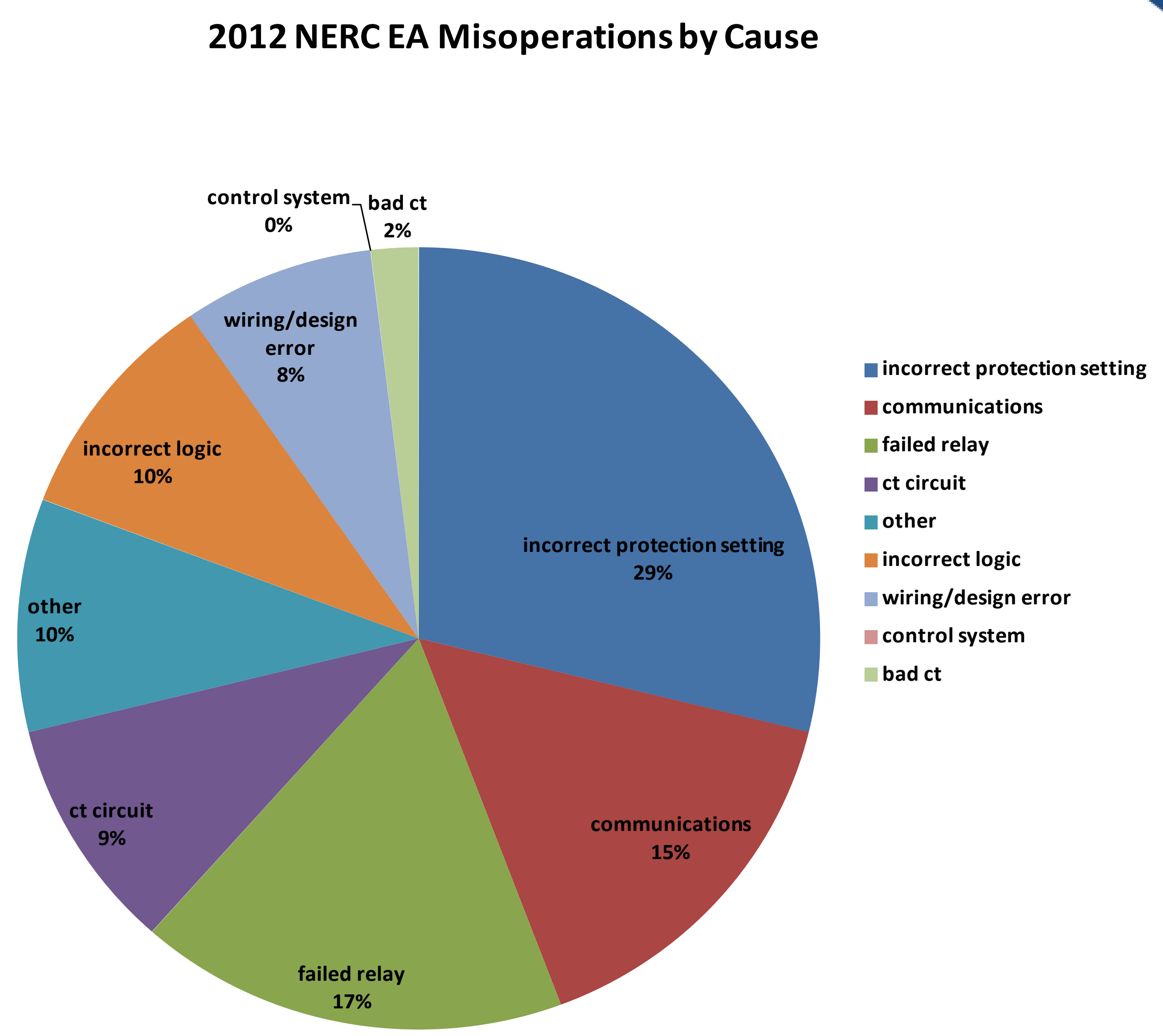
2012 Event Analysis

- NERC Event Analysis
  - 2012
    - 116 Category 1-5 Events
    - 42 Events with Misoperations

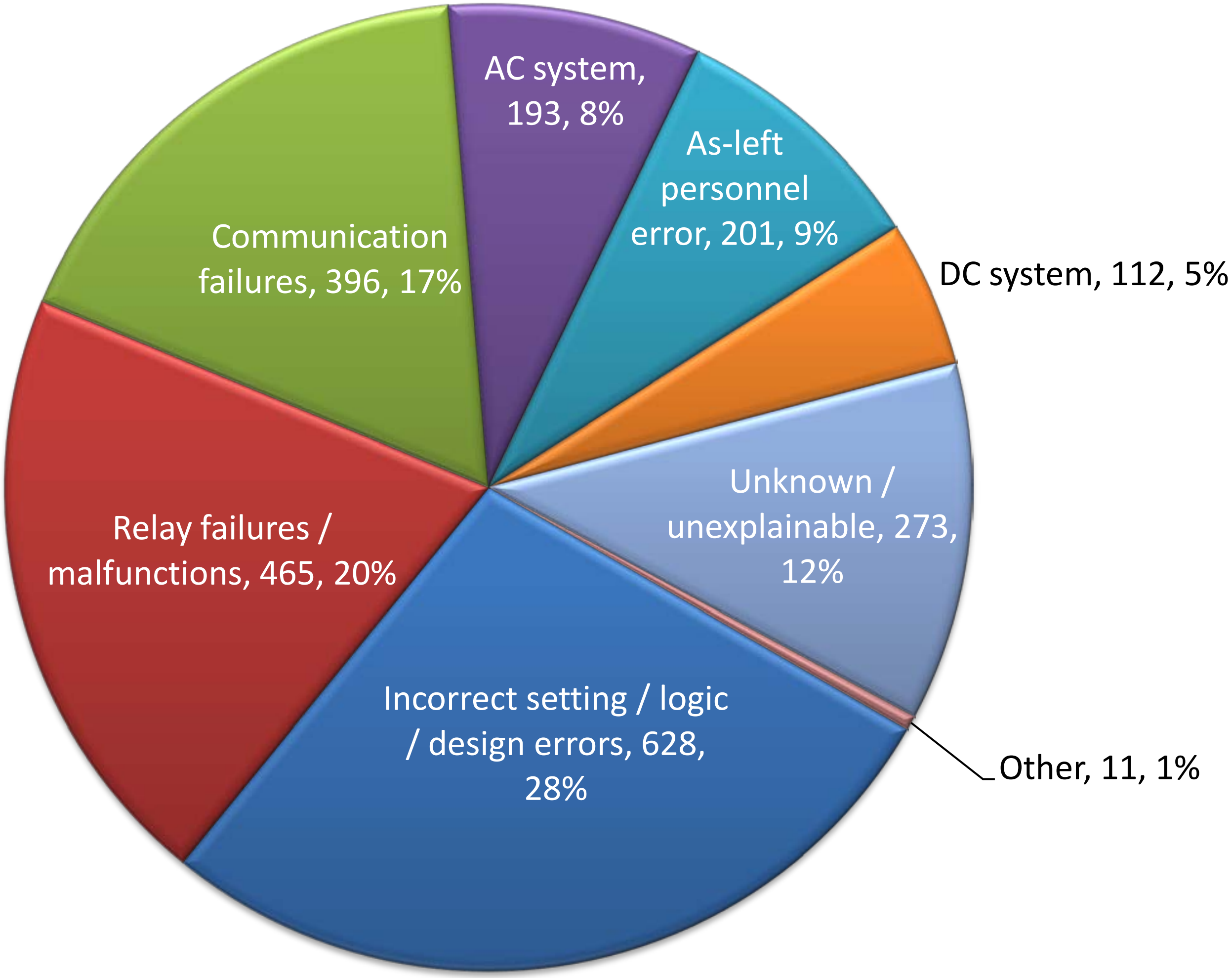


2012 EA Misoperations

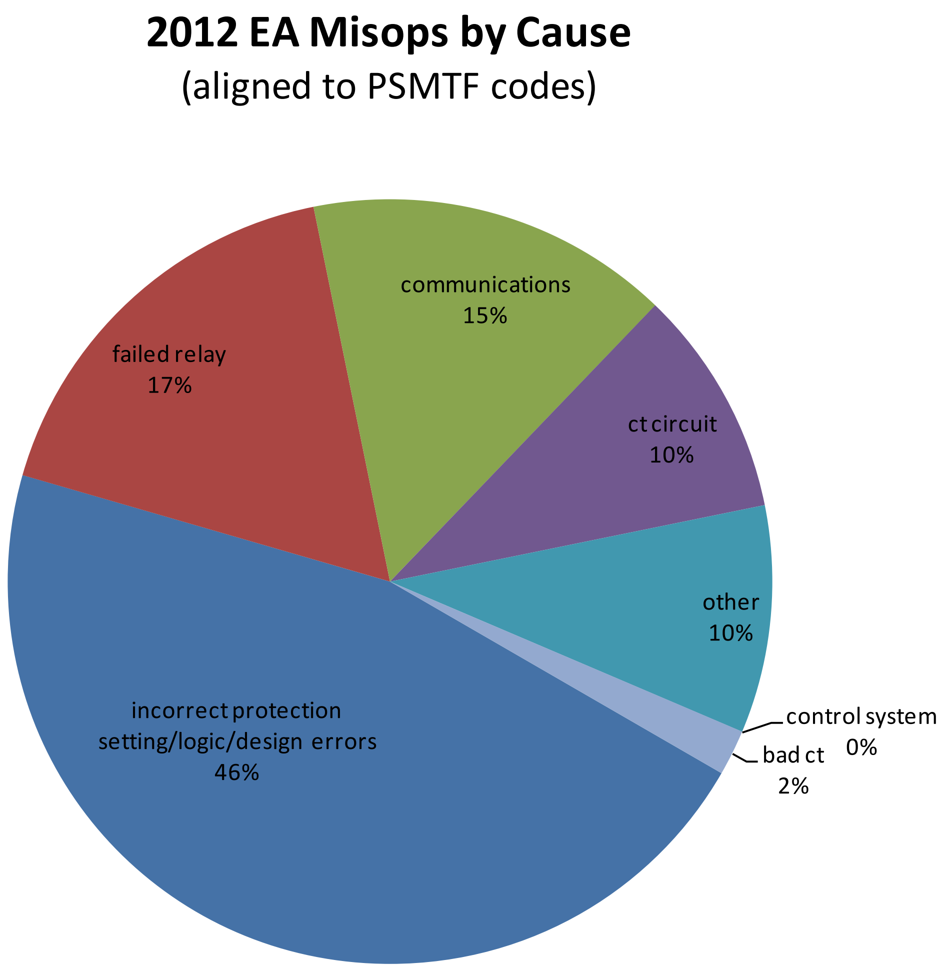


PSMTF Data

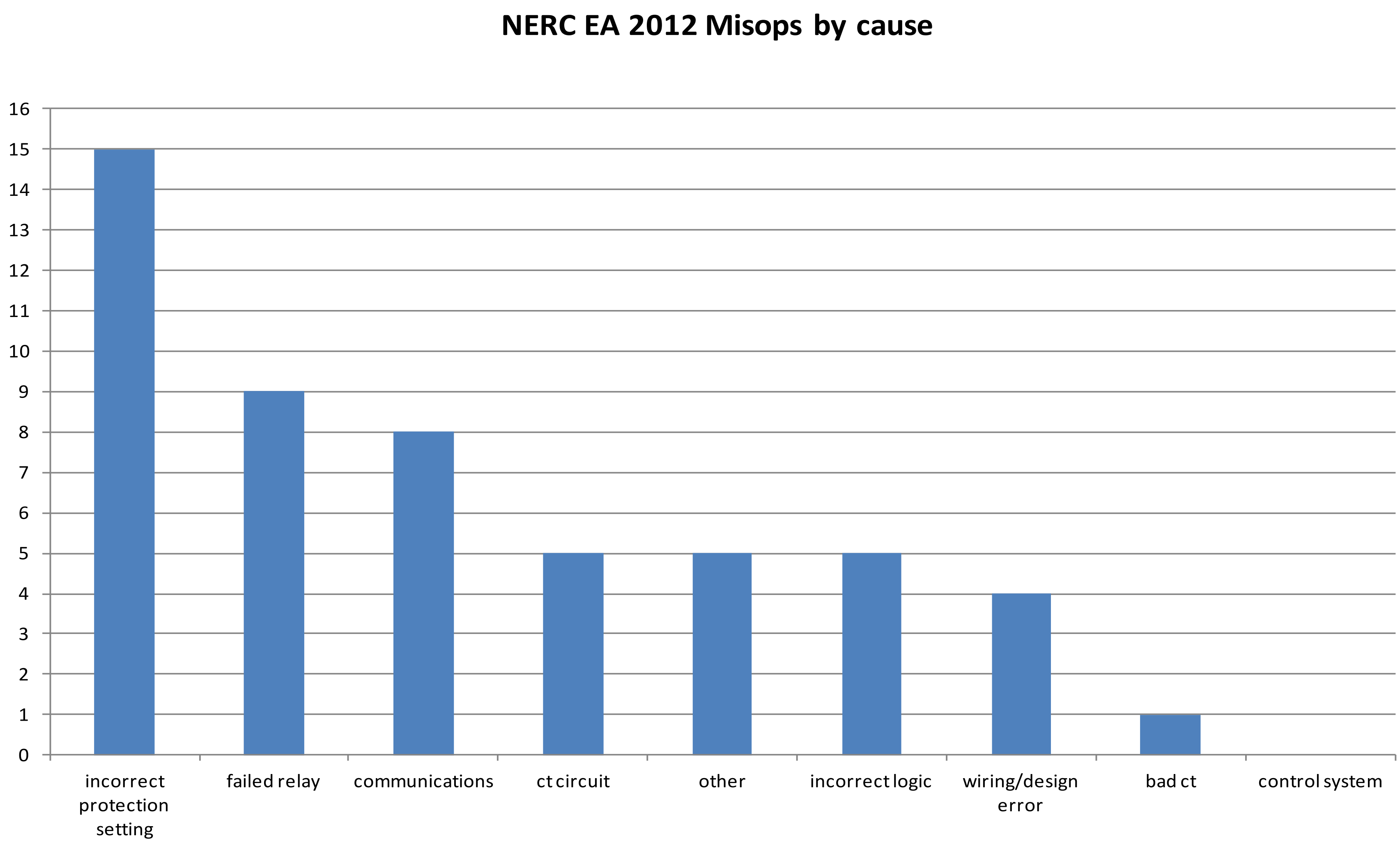
NERC-wide Misoperations by Cause Code (Jan 1, 2011 – April 1, 2012)



2012 EA Misoperations Causes Aligned to PSMTF Categories



NERC EA 2012 Misops by Cause



NERC Event Analysis Cause Coding

- A1 – Design / Engineering
- A2 – Equipment / Material
- A3 – Individual Human Performance
- A4 – Management / Organization
- A5 – Communication
- A6 – Training
- A7 – Other
- AZ – Unable to determine root cause

2012 Events – 43% AZ

NERC Event Analysis Cause Coding

Reference Material for Cause Analysis Methods & Tools

http://www.nerc.com/page.php?cid=5|365

Preliminary 2013 Events

- Preliminary 2013 Event Analysis as of 4/30/2013
  - 33 events
    - 10 Misoperations

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Protection System Misoperations Task Force

Report Key Findings

Andy Slone, NERC, Reliability Performance Analysis Engineer
Richard Quest, MRO, Principal Systems Protection Engineer

May 7, 2013

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Protection System Misoperations Task Force (PSMTF) History

- PSMTF formed by NERC Planning Committee in March 2012
- PSMTF composed of protection system experts from all 8 Regional Entities to:
  - Analyze relay misoperation data
  - Research root causes
  - Develop industry recommendations to reduce future relay misoperation occurrences
- Throughout the process, PSMTF coordinated with NERC System Protection and Control Subcommittee (SPCS)

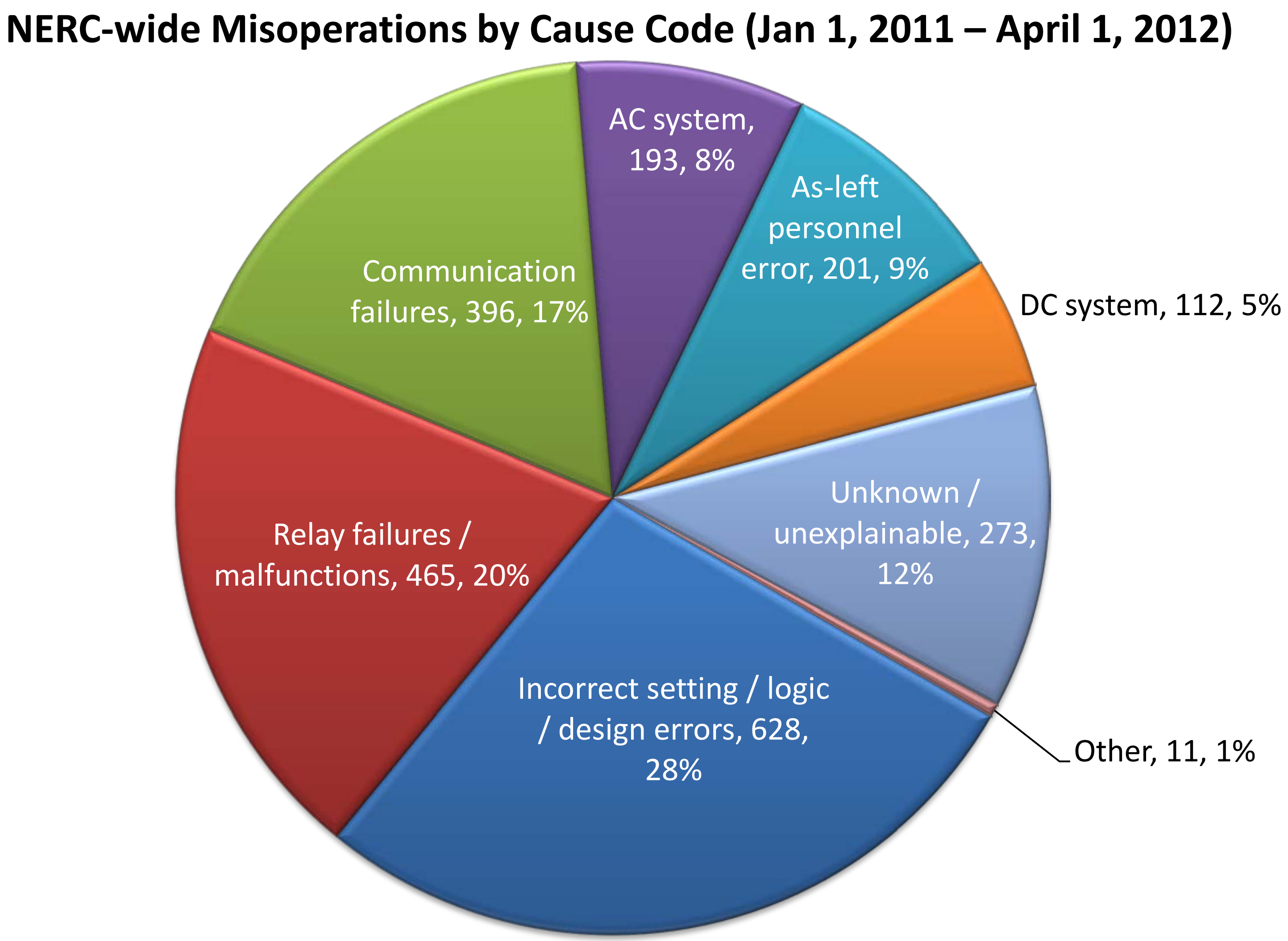
Protection System Misoperations Task Force (PSMTF) Analysis

- Reviewed historical (pre-2011) Regional Entity misoperations
- Analyzed misoperations from January 1, 2011 to April 1, 2012 submitted in NERC misoperations template
- Focused on top 3 misoperation causes:
  - Incorrect settings/logic/design
  - Relay failure/malfunction
  - Communication failures
- Classified misoperations in top 3 misoperation causes by sub causes
- Based on the analysis of top issues, developed suggestions for improvement to reduce top misoperation areas
- Recommended data monitoring and data improvements

Regional (Pre-2011) Look Back

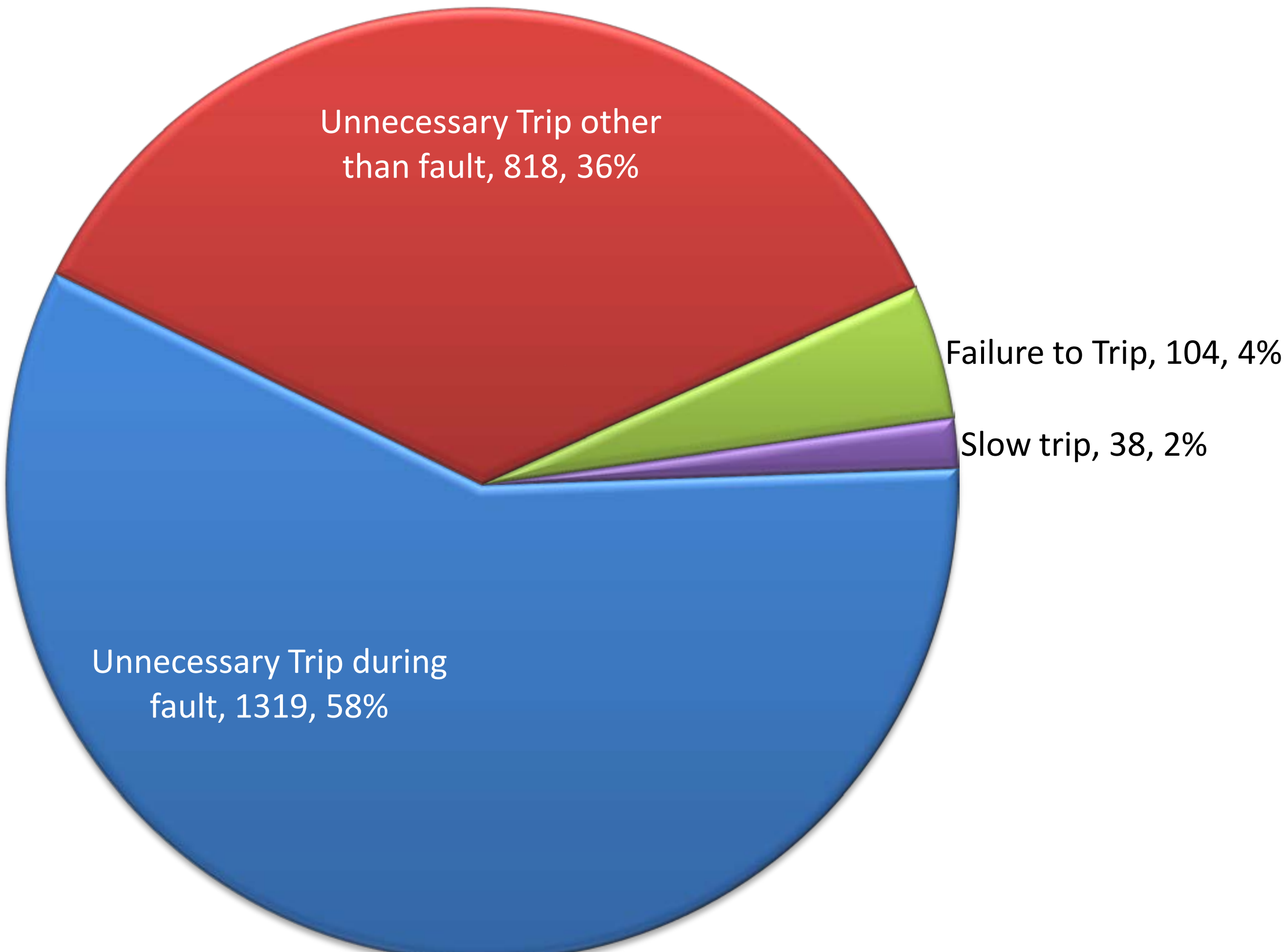
- Reviewed historical (pre-2011) Regional Entity misoperations
- Top 3 misoperation causes from pre-2011 Regional Entity data
  - Incorrect settings/logic/design errors
  - Relay failures/malfunctions
  - Communication failures
- Supported top causes of 2011Q1-2012Q1 misoperations

Misoperations by Cause Code



Misoperations by Category

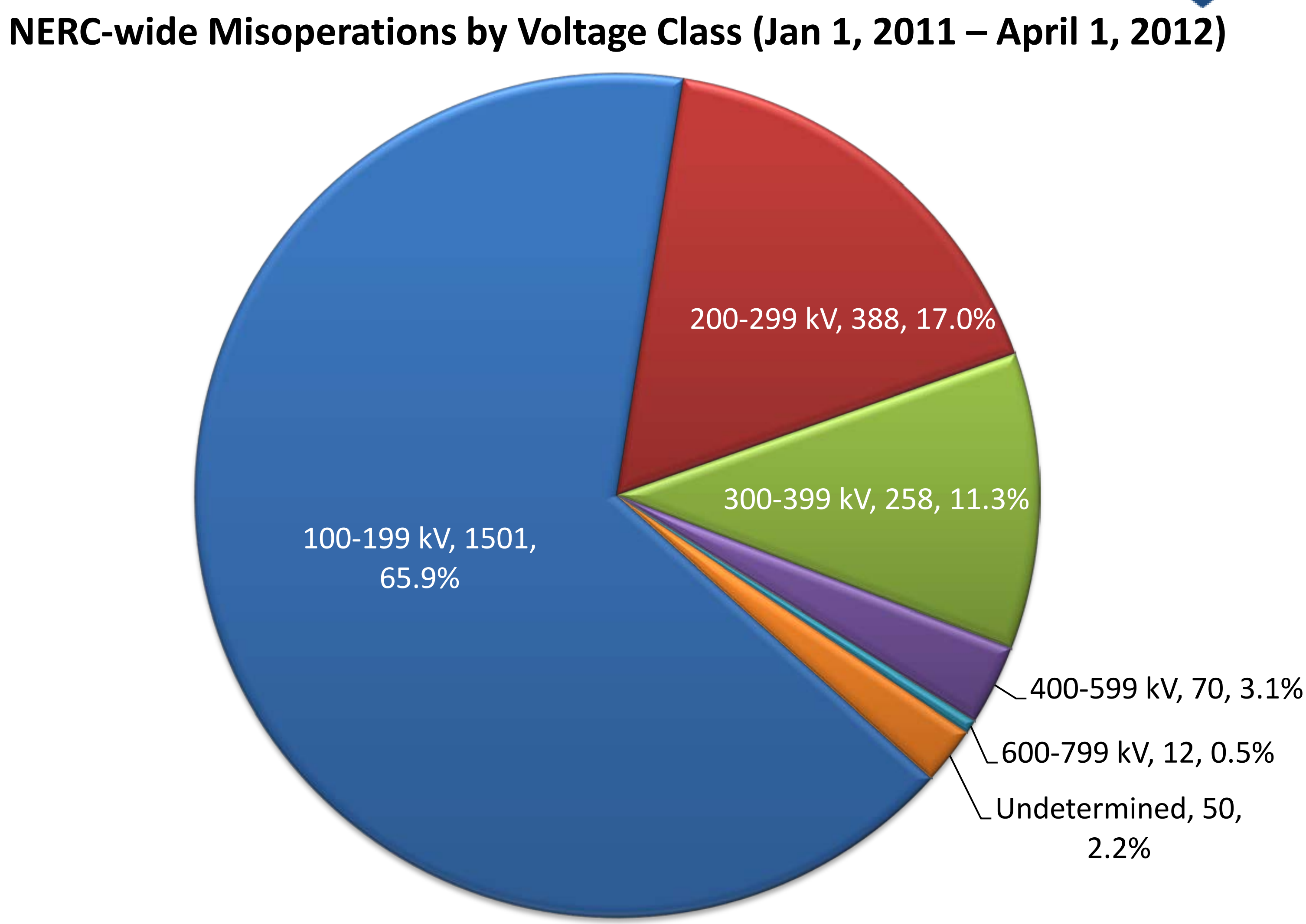
NERC Wide Misoperations by Category (Jan 1, 2011 – April 1, 2012)



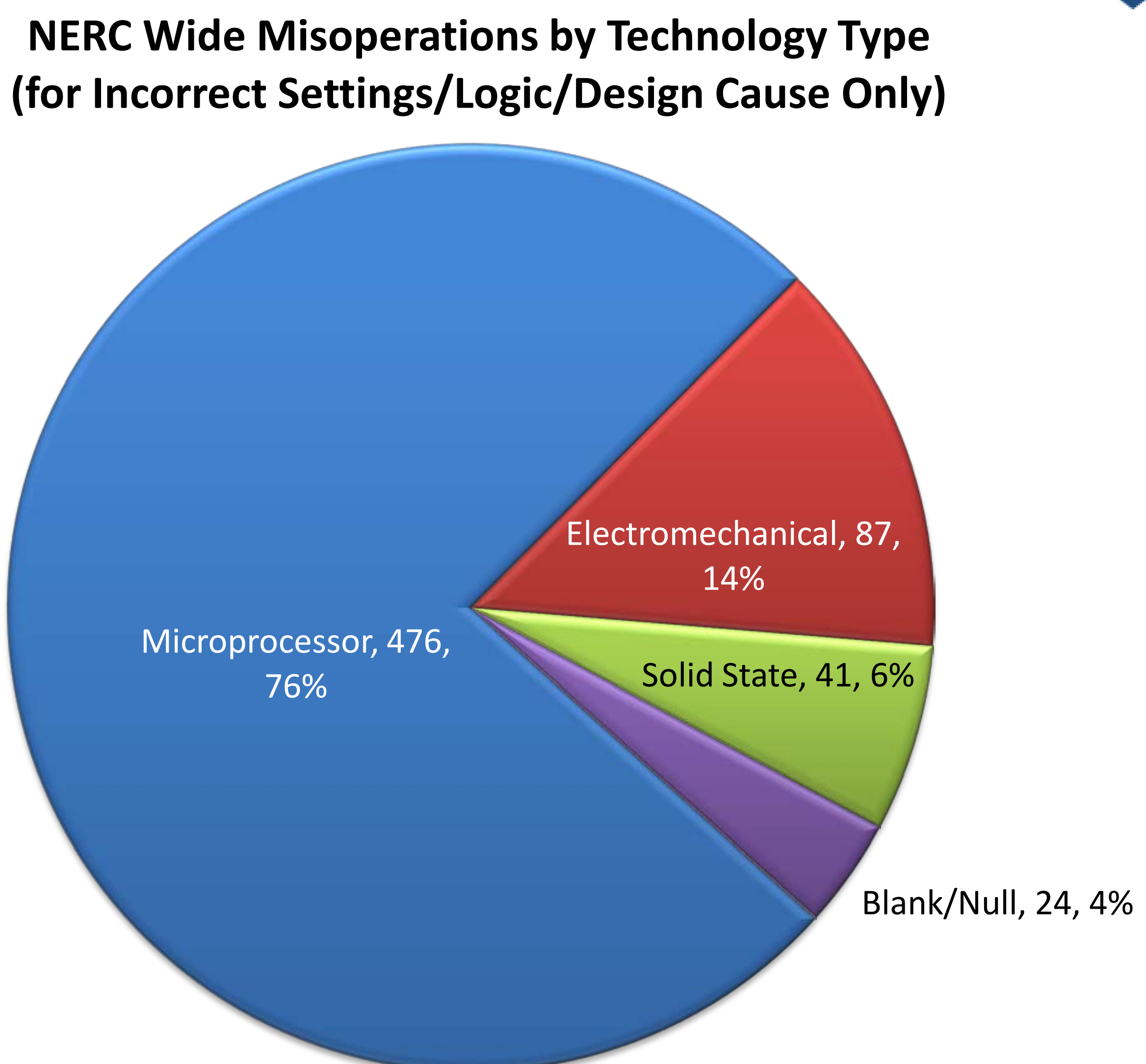
Dependability and Security

- Approximately 94% of misoperations in the study period resulted in unnecessary trips.
- Only 6% resulted in a failure to trip or slow trip.
- However, as the power system is worked closer to its limits, planners and protection engineers and other interested parties should work together to determine proper protection system scheme application and setup to ensure proper emphasis on both dependability and security.

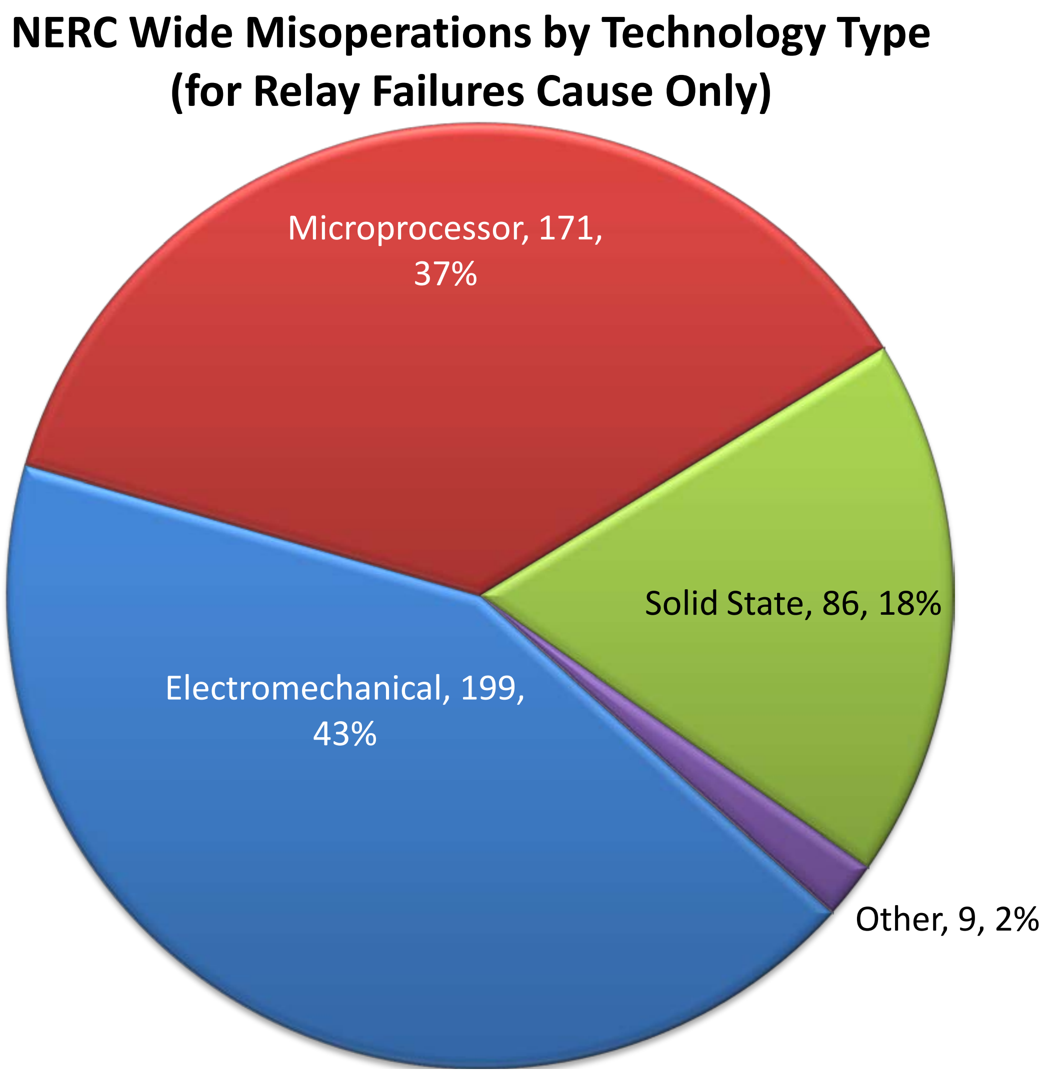
Misoperations by Voltage Class



Misoperations by Technology Type



Misoperations by Technology Type



PSMTF Misoperation Analysis

- To maximize effort, focused on top 3 misoperation causes (1,489 or 65% of the misoperations):
    - Incorrect settings/logic/design
    - Relay failure/malfunction
    - Communication failures
- Three teams analyzed each misoperation by category
- Categorized misoperations by second and (if possible) third level causes

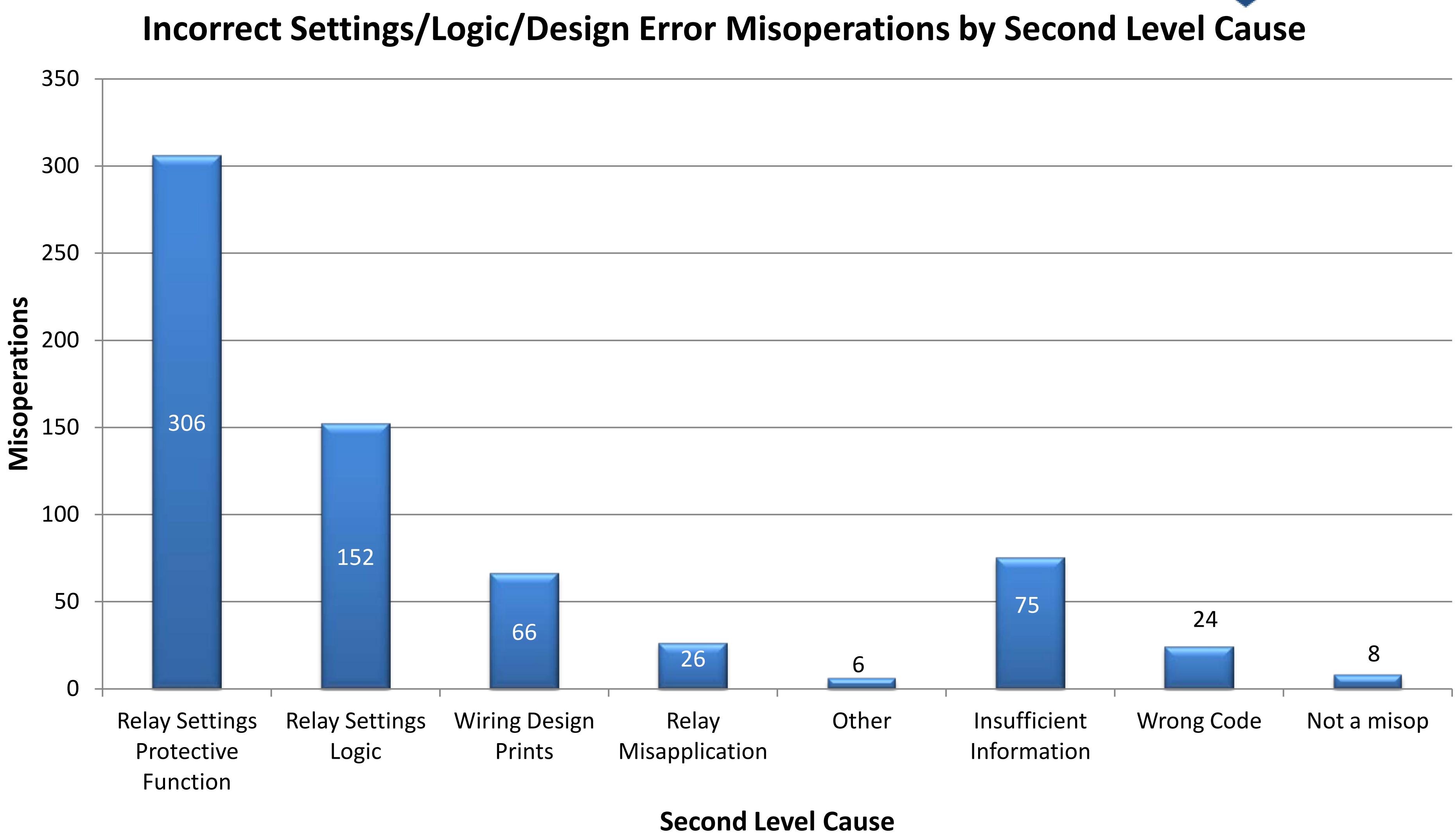
PSMTF Teams

- Settings/Logic/Design Errors
  - John Zipp (Lead), ITC Holdings
  - Rick Gurley, American Electric Power
  - Richard Quest, Midwest Reliability Organization
  - Thomas Teafatiller, Southwest Power Pool, Inc.
- Relay Failures/Malfunctions
  - James Ryan (Lead), Florida Power & Light Co.
  - Randy Spacek, Avista Corp.
  - Ken Behrendt, Schweitzer Engineering Laboratories
  - Quoc Le, Northeast Power Coordinating Council
- Communication Failures
  - John Miller (Lead), Georgia Transmission Corporation
  - Alex Echeverria, New York Power Authority
  - David Greene, SERC Reliability Corporation

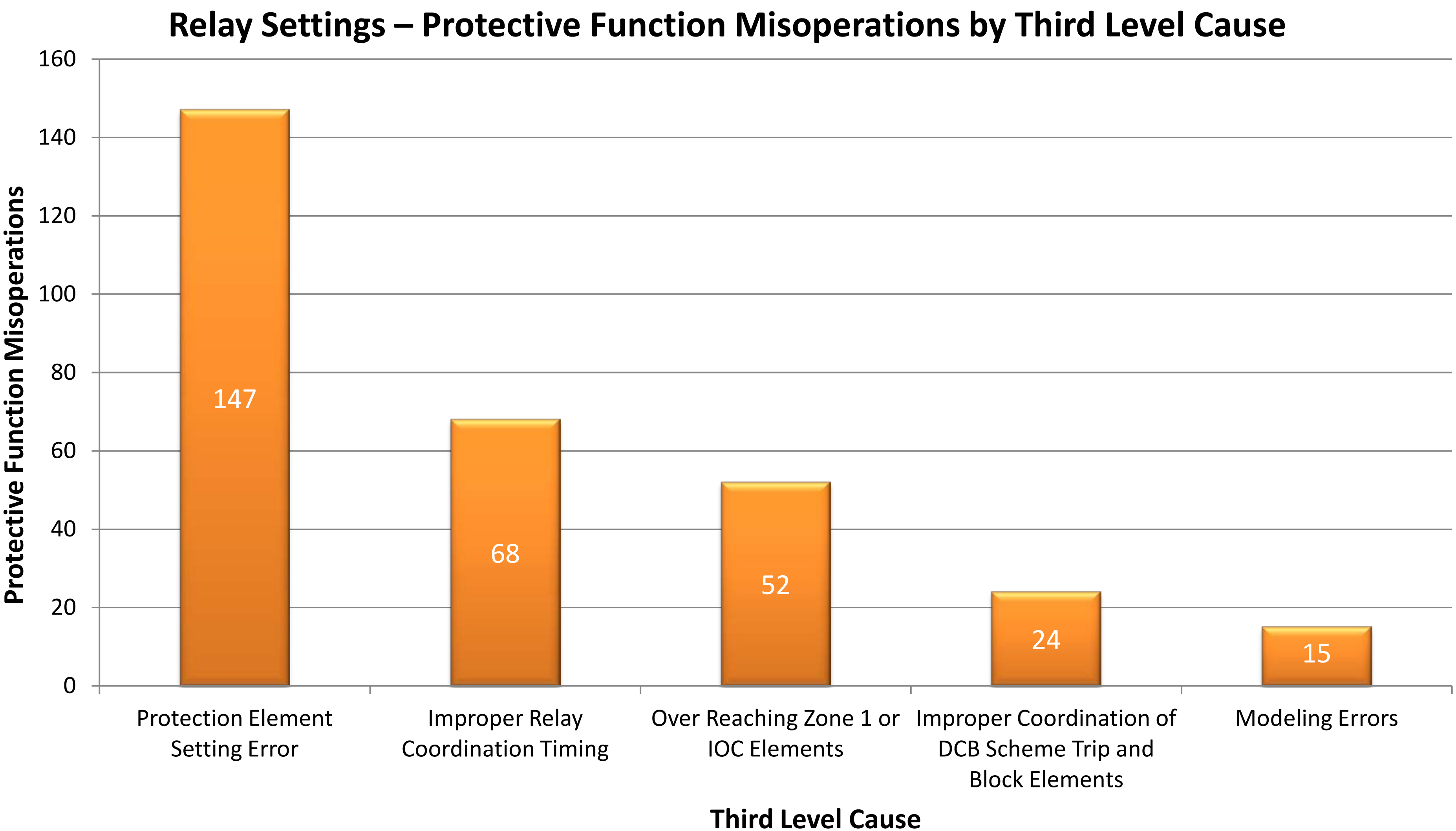
Incorrect Settings/Logic/Design Errors

- This category includes misoperations due to “engineering” errors by the protection system owner. These include:
  - Setting errors;
  - Errors in documentation;
  - And errors in application.
- Examples include:
  - Uncoordinated settings;
  - Incorrect schematics;
  - Or multiple CT grounds in the design.

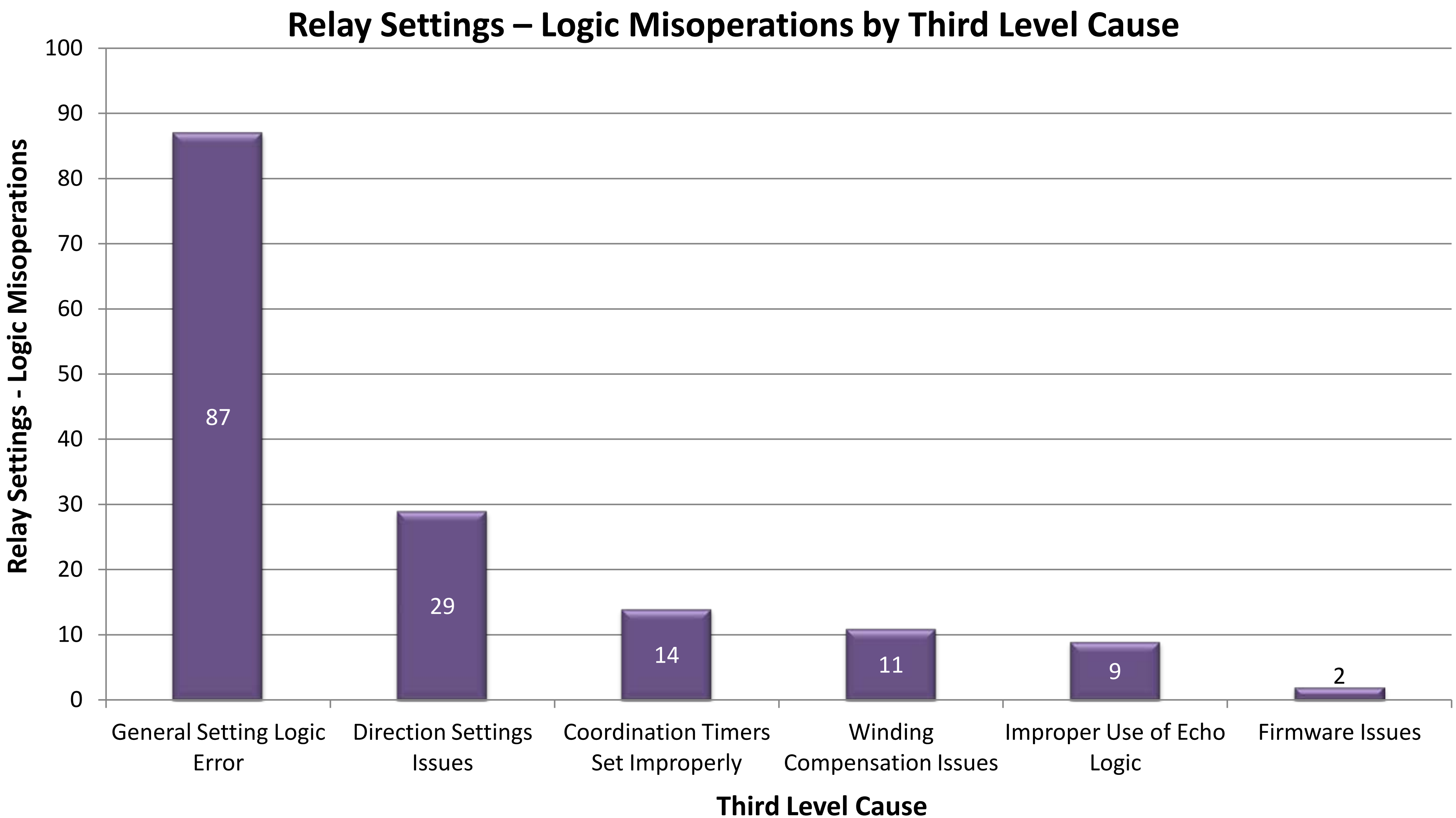
Incorrect Settings/Logic/Design Errors by Second Level Cause



Relay Settings – Protective Function Misoperations by Third Level Cause



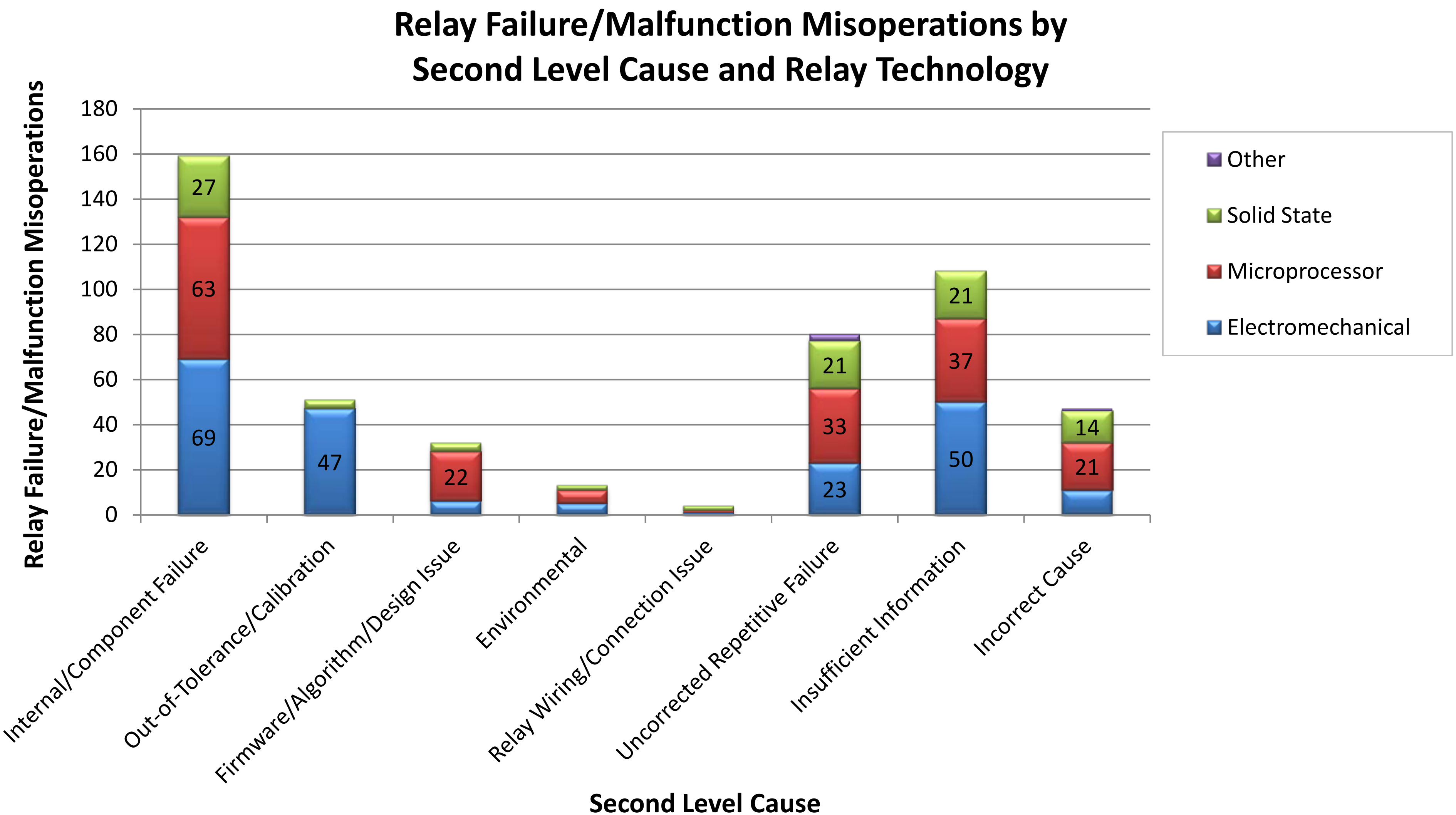
Relay Settings – Logic Misoperations by Third Level Cause



Relay Failures / Malfunctions

- This category includes misoperations due to improper operation of the relays themselves.
- These may be due to:
  - Component failures;
  - Physical damage to a device;
  - Firmware problems;
  - Or manufacturer errors.
- Examples would include Misoperations caused by:
  - Changes in relay characteristic due to capacitor aging;
  - Misfiring thyristors;
  - Damage due to water from a leaking roof;
  - Relay power supply failure;
  - Or internal wiring/logic error.
- Failures of auxiliary tripping relays fall under this category.

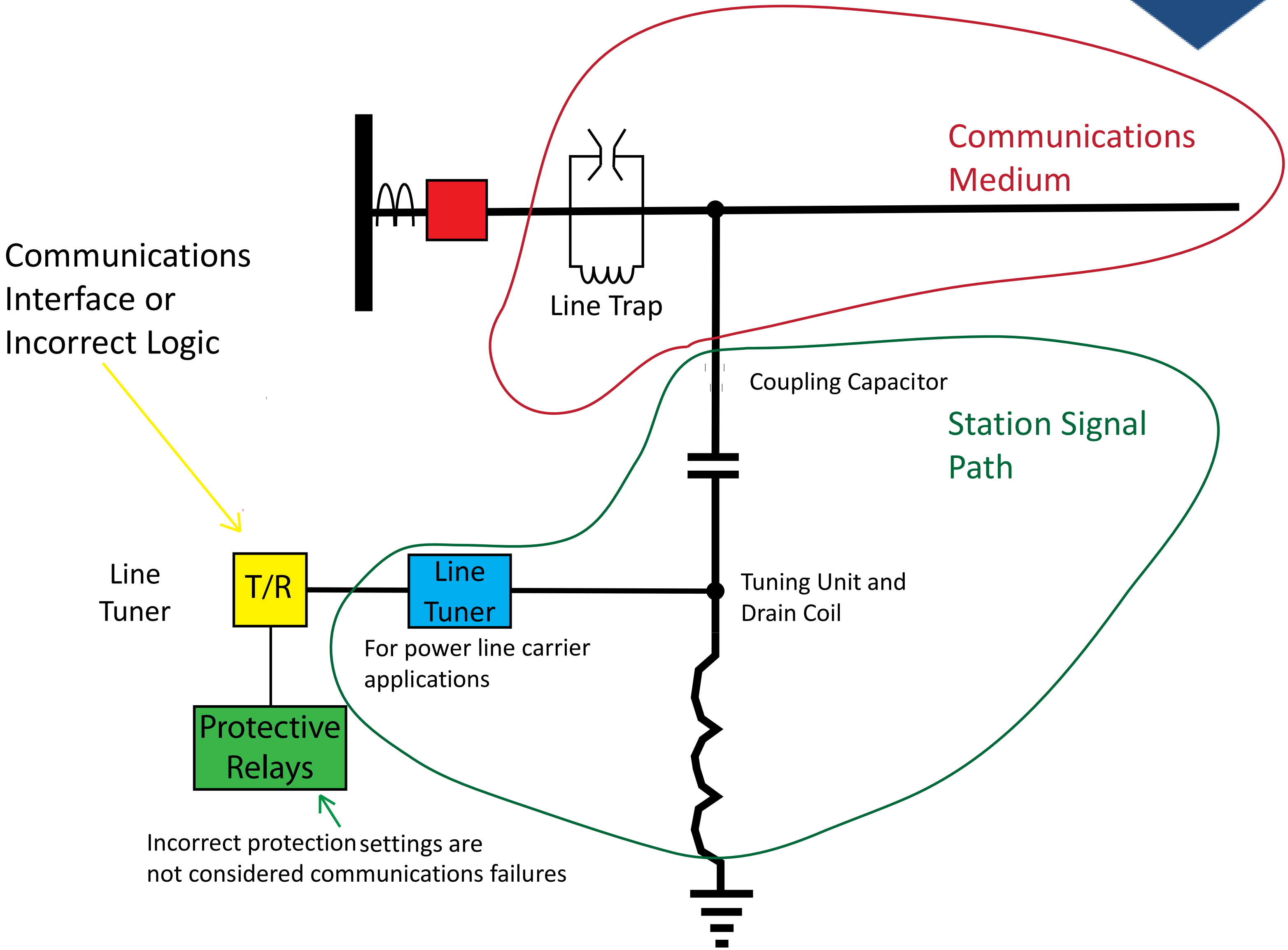
Relay Failure / Malfunction Misoperations by Second Level Cause and Relay Technology



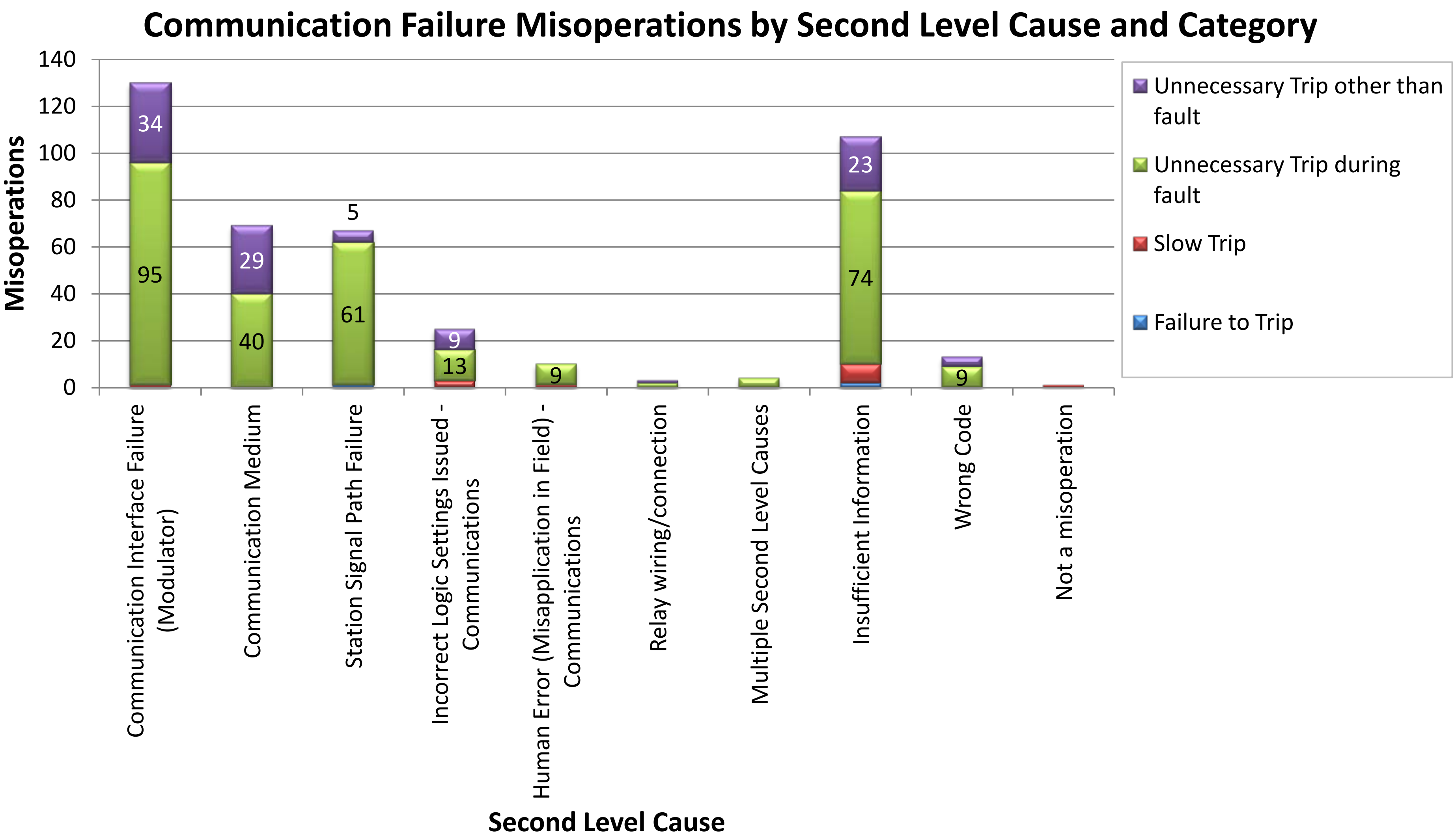
Communication Failures

- This category includes misoperations due to failures in the communication systems associated with protection schemes inclusive of transmitters and receivers.
- Examples would include misoperations caused by:
  - Loss of carrier;
  - Spurious transfer trips associated with noise;
  - Telco errors resulting in malperformance of communications over leased lines;
  - Loss of fiber optic communication equipment;
  - Or microwave problems associated with weather conditions.

Power Line Carrier Communications Component Diagram



Communication Failure Misoperations by Second Level Cause and Category



Suggestions for Improvement

- Proper Application of Relay Elements
- Settings Errors
- Microprocessor-based Relay Firmware
- Application of Power Line Carrier Communication Aided Protection
- Performance Monitoring and Data Improvements

Proper Application of Relay Elements

- Applications requiring coordination of functionally different relay elements should be avoided.
- If these applications cannot be avoided, the coordination should be studied and tested thoroughly.
- This type of coordination is virtually always problematic, and is the cause of numerous misoperations reported in the study period.
- Some examples to avoid include:
  - Coordinating distance elements with overcurrent elements
  - Directional overcurrent elements at opposite line terminals that use different directional polarization methods, particularly in the same pilot scheme
  - Coordinating overcurrent elements that use different measurement methods, such as phase vs. residual ground vs. negative-sequence current measurement

Settings Errors

- Misoperations due to setting errors can potentially be reduced.
- Techniques that could be used to reduce the application of incorrect settings include:
  - Peer reviews
  - Increased training
  - More extensive fault studies
  - Standard templates for setting standard schemes using complex relays
  - Periodic review of existing settings when there is a change in system topography
- The IEEE Power System Relaying Subcommittee, IEEE PSRC, published a working group report to provide additional technical guidance for protective relay setting quality control.
  - http://www.pes-psrc.org/Reports/Processes_Issues_Trends_and_Quality_Control_of_Relay_Settings.pdf

Microprocessor-based Relay Firmware

- Entities should evaluate the need to apply updated firmware.
- While many firmware updates may not be critical to the relay protection functions, updated firmware that corrects critical protection functions should be given priority.
- IEEE Standard C37.231, IEEE Recommended Practice for Microprocessor-Based Protection Equipment Firmware Control
  - Discusses various aspects of firmware version control and provides guidelines for the effective administration of firmware-related issues.

Application of Power Line Carrier Communication Aided Protection

- Momentary signal loss (holes) sometimes caused by protective spark gaps firing during the fault.
  - Spark gaps need to be inspected for build up and for the proper, manufacturer-required gap.
- Use of a carrier hole override timer on digital systems may be used as a means to reduce misoperations.
  - While carrier hole timers can provide added security to DCB schemes, they can mask carrier system setting or component deficiencies.
  - The decision to apply this logic should be weighed carefully.
- Modern check-back equipment is helpful to detect the failure to perform a carrier test.
  - Provides better communication scheme condition indication than many older check-back test schemes
  - Alternatively, frequency shift keying (FSK) carrier can be used with microprocessor based
- Resources for Power Line Carrier Communication Aided Protection
  - **A Reliable Power-Line Carrier-based Relay System**, Miriam P. Sanders, P.E. (Quanta Technology, LLC).
  - **Investigation and Analysis into the Mis-Operation due to Carrier Holes**, John J. Meinardi, Florida Power & Light Co., and Miriam P. Sanders, PE – AMETEK Power Instruments, Copyright 2008.
  - **Special Considerations in Applying Power Line Carrier for Protective Relaying**, IEEE Power Systems Relaying Committee Special Paper.

Performance Monitoring

- Detailed misoperation analysis should be continued on at least an annual basis by the respective Protection System Subcommittees within the Regions.
- This analysis will be forwarded to the NERC SPCS and NERC Performance Analysis Subcommittee for trending and metrics reporting.
- Adequate Level of Reliability Metric (ALR4-1) to monitor misoperations
  - http://www.nerc.com/page.php?cid=4|331|400

Data Improvements

- Misoperations with Insufficient Information
  - High percentage (over 24%) of misoperations did not have enough information to subcause
  - Improved data submission by entities would improve accuracy
- Consistency in Reporting
  - Improved Event Description field instructions to guide entities on needed information
  - Entities should verify with neighbors when tie-line misoperations occur to avoid double counting
- Reporting Multiple Occurrences
- Template Enhancements

Questions and Answers

Thank You!

If you have any additional questions, please contact:

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