Misoperations Summit Report
October 26, 2016

On behalf of the SPP System Protection and Control Working Group (SPCWG) and the SPP Reliability Compliance Working Group (RCWG), the following summary report is submitted for consideration and action of the collective Working Groups.

Executive Summary

The SPP Member Companies have been focused on Misoperations performance and working on ways to improve those performance statistics. This had been historically accomplished through discussions within the SPP SPCWG and white papers were completed to encourage improvements. The improvements were not as measurable as the Member Companies had desired. The creation of the Misoperations Summit was to encourage a broad group of SPP Member Company experts with regulators to collaborate for improvements. The post event survey suggested the Summit was a success for the members and created information with a clear path for follow up to generate opportunities to pursue. Details are provided in the full report below.

Recommended Actions

1. **Initiate a follow up event for next year to pursue specific improvement opportunities.**
2. **More actively involve the technical experts which is where the real improvements can occur.**
3. **Determine path for proactive review of Misoperations before submission.**
4. **Identify "frequent fliers" for targeted discussions and assistance to improve overall performance metrics.**
5. **Create a Misoperations resource library.**
6. **Continue to identify and evaluate opportunities for collaboration with peers and regulators.**

I. Purpose

To create an event to encourage a broad group of SPP Member Company experts and regulators to collaborate for improvements to misoperations performance.

II. Current State Definition

- SPP was reported as one of the worst performing in misoperations.
- SPCWG performed additional analysis but single causal issues were not readily apparent.
- Member companies and Registered Entities were struggling with at least three things:
    - Reporting consistency for discussions,
    - Areas of focus, and
    - Action paths forward.

- SPCWG produced white paper(s) as requested to try to provide guidance and assistance to the SPP members.

III. Examples (*see questions in the Presentation_MisoperationsSummit 2016 on pages 59 – 80. Provide the answers and capture each page as Team 1, 2, etc. We looked at questions 4 and 6 specifically – analysis captured below.)*

Example 4: Description of Misoperation/Failure

A single-end trip occurred on a 161 kV line during a thunderstorm. There was no loss of load, since the line remained energized from the opposite end. The cause of the trip was determined to be a false instantaneous input to the relay due to a voltage spike caused by lightning. The line is in close proximity to sensitive transmission and distribution equipment and the settings in the relay were valid according to documented calculations developed with the information available prior to the event. However, upon further investigation of the circumstances of this event, engineering personnel recommended a 1/4 cycle delay setting be added to possibly prevent this from happening in the future.

Example 6: Description of Misoperation/Failure

There was a fault between Sub A and Sub B, Sub B is a Sectionalizer substation. Breakers at Sub A and Sub C cleared the fault as expected. The sectionalizing breaker R1-4 at Sub B failed to open and sectionalize the line as it should have causing the line from Sub A to Sub C to lockout.

- Do you consider this event a Misoperation?
- Do you believe this event could have been prevented?
- How would you assess the risk of this event to BES? Minimal, Moderate, High?
- Do you believe this event should be included in the NERC Misoperation Information Data Analysis System (MIDAS) Reporting?

Team	Question 1	Question 2	Question 3	Question 4	Question 5
Team 1	Yes	Ops, misops, root causes, potential and actual impact to BPS, voltage/load data, maint cycle/history/schedule, reportable events, cause codes	Reduction in misops, reduction in corrective maint (due to preventative), enter misops data (cause codes, frequency, etc) into charts, compare against historical data	Yes	That preventative actions increase reliability, program is currently effective. Is program sustainable? If not, recommend adjustments. If so, recommend continuation. Recommend reviewing to see if similar program could be applied elsewhere.
Team 2	Yes	Root cause, granular cause codes, by entity equipment type, repeats by element	Cause-code level, process and programs used to manage assets, cooperative	Yes	Are CAP's effective? Definitive cause correlations

			culture/active program to reduce misops, preventative measure effectiveness		
Team 3	Yes	Current misop data and near miss	Reduction in misops	Yes	--
Team 4	Yes	Reoccurrence/ trends, cause	Common cause, determining cause	Yes	Cause, mitigation
Team 5	Yes	Ops, weather, projects/outages, manufacturers, relay type, system changes, repeat misop	Small gradual changes	Yes	Validation that changes improved BES reliability
Team 6	Yes	Misops, alarm relay events/ every event, reliability impact, “near miss” data, correct relay ops data (repeat ops), problems found in commissioning, equipment vintage/asset management tools	Hopefully downward misops, reliability improves (note might take time to detect trend)	Yes	Would like leaping indicators with actionable countermeasures.
Team 7	Yes	Voltage rating, scheme, monitored component, manufacturer MIDAS info, environmental factors, near misses capturing errors	Weather related, manufacturer, design errors, construction error, age	Possibly, some will	Definitive indicators for error sources
Team 8	Yes	Lots. Better stratification of data on high priority assets/systems. Highest risk- associate with reliability of BES	Time series data. Expect to see less BES events associated with misops	Yes	ID causes for corrective actions, ID trends, ID targeted solution
Team 9	Yes	All: misops, cause, subcause, voltage level, equipment type, microp/EIM, risk, scheme type	Dependent on weather/seasons, decreasing numbers in categories attention is paid to, manufacturer/ deployment dependent	Of course	Root cause- eliminate repeat offenses

IV. Hypothesis and Risk

Misoperations related to _____ are due to _____.

If countermeasure _____ is implemented, then there will be a significant reduction in Misoperations related to _____.

Misoperations related to (column 1) are due to (column 2):

As-left personnel error	human & organization performance
Relay failures/ malfunctioning	The lack of comprehensive maintenance program
Incorrect settings	Lack of knowledge
Design errors	Human error & lack of experience
DC System	Wiring errors
Incorrect settings	Unknown variables (complexity, system changes, planning studies, inherent setting philosophy
As-left personnel error	Contractors or inexperienced personnel
Logic errors	Complexity of logic/scheme, lack of I/O connection understanding, lack of training, confusion regarding element naming, improper use of echo logic, tripping equation includes improper/incorrect elements, inability to visualize logic (schematics)
Logic errors	Non–standard designs
Relay failures	Firmware bugs
DC Systems	Trip circuit failure
As-left personnel	Commission testing, contractor oversight after commissioning new facilities
AC system	Rodents, CT Saturation, potential devices on voltage unbalance schemes, failed CCVT: (Transient response, blown up, partial failure), mis-wired diff scheme
Communication failures	Carrier holes
Incorrect settings	Software tool Aspen Relay Database: official repository for relay settings, tracks setting changes, provides signature trail of: request, approval, issuance, completion, verification
Communication failures	Equipment failure (owned)
AC system failures	Phasing errors

If countermeasures are implemented, then there will / could be a significant reduction in:

Barriers and controls	Process and procedure
Comprehensive maintenance program that includes an aggressive preventative maintenance & evaluation of root causes (with wide angle deployment of mitigation; checklists; supervisory oversight, etc.)	Relay failures/ malfunctions
Training, peer/third party review templates	Incorrect settings
Training, commissioning, peer review, and quality control	Design errors
Independent drawings & detailed commissioning test	DC Systems
Peer review of setting criteria	Incorrect settings
Checklists, training, peer review, technology	As-left personnel error
Logic visualization tools: Peer review, standard schemes/logic, commissioning procedure verify logic settings, training, logic diagrams for each scheme (with controls to ensure they are used)	Logic Errors
Standard template and peer review	Log errors, testing errors
Upgrade firmware	Firmware bugs
Active monitoring of DC Control Circuit	Early detection of DC circuit failures
Computerized testing/ tool that requires correct readings before moving on	As-left personnel error
BTXD Block Trip Extension Delay Timer, maintain spark gap, Co-Ax maintenance, thorough review of event records for external faults looking for carrier holes	Communication failures
Reduction of errors	Number of Misops due to reduced setting errors
If entity owned equipment: Testing & Maintenance program, equipment service bulletins. If NOT entity owned: contracts, litigation, develop legislation in supporting BES to Communication companies	Communication failures

Countermeasures: Choose a countermeasure that could be implemented to reduce Misoperations while concurrently reducing the risk to the BES, and describe how it would be implemented (e.g., tools, processes/procedures).

What is the relationship between your countermeasure and increased reliability?	*What data would you collect to document this relationship?*
Decrease in misops due to design errors	Downward trend of errors due to errors caught during peer review
Active monitoring	Digitals relays- ensuring active monitoring is enabled Electromechanical- deploy active monitoring hardware then monitor detection system (alarms) and take appropriate action which reduced risk to BES by proactively detecting component failures.
Validate phasing using "some method"	Increased reliability: large effect on auto-XFMR & GSV operations
Peer review process	Implementation: design review of drawings, review of settings, review/witness point-to-point, coordination between design and settings engineers, functioning and baseline tests
Independent drawing reviews	Rigorous drawing management system, most current drawings available, documented process, centralized location to store drawings
Commissioning testing- validate and prevent to avoid event risk	Checklist of tested elements and expected results (protecting equipment specific) Commissioning sheets from Manufacturer's/ OEM (based on lab test potentially don't miss operational expertise) Protected element/logic testing also to validate Related to commissioning of asset of "facility" Baseline, records capture- for issue spotting Entity coordination
Remove settings from highest risk stations for 3rd party review (prior to misops)	Direct impact to increase reliability allowing time for errors to be corrected and use findings/recommendations to reduce incorrect settings
Training	Leads to walk-downs and consistency
Improves information flow to field and logic development by providing structure	Reduction in reported misops due to logic errors, as well as number of errors found during commissioning
Less misoperations due to over tripping and communication failures	Event records to look at length of carrier hole
Communication failures/ carrier holes- install BTXD timer on all capable relays and identify particular CCVT's that are prone to carrier holes	Review event records on lines with suspect CCVT's
Cats, outdoor cables in conduit, physical barriers (armor), higher CT ratio (mindful of lead resistance in field testing), consider all breaker configurations, buy C800 CT's	Be aware of appropriate application of devices, voltage monitoring to catch issues early, better commissioning practices.

Data Analysis and Brainstorming

- What data should be collected analyzed?
- What trends in the data might you expect and how can you detect those trends?
- How can the data you're proposing to collect illustrate the impact of countermeasures?
- What conclusions and recommendations would you like to be able to draw from the data?

	What data should be collected analyzed?	What trends in the data might you expect and how can you detect those trends?	How can the data you're proposing to collect illustrate the impact of countermeasures?	What conclusions and recommendations would you like to be able to draw from the data?
Team 1	Logic diagram of all user-defined logic	Site and application specific	Shows all inputs, times, and outputs. Allows review of settings	Requires good configuration management to incorporate changes. Improves field review
Team 2	Peer reviews	Implemented in various phases or areas: design, field	Increase in findings/correcting potential errors prior to implementation = Increase in BES reliability due to decrease in misops	Looking at failure rates before and after implementation
Team 3	AC System: Incorrect phasing/ differential schemes	Primary current injection: test equipment (specialized), safety/switching clearances Secondary wiring is not disconnected: phasing, CT ratio and Aux CT's, wiring, relay Earth shattering relationship	Develop sub-causes for AC system	Near miss reporting of problems found
Team 4	Valid alarms	Root cause analysis	Corrective actions	Performance data, review and assess data for systemic issues
Team 5	Maintenance records, equipment performance, manufacturing type, commissioning records, voltage level, number of misoperations from unknown cause, electromagnetic stats, e-static	Relationship to load loss, relationship to event, relationship to interruptions, contractor vs in-house performance, settings, maintenance sufficiency, communication opportunities, testing changes	Dedicated source for prioritizing resources, microprocessors causing more issues	Efficient prioritization of resources

V. Questions Captured

- 8% Misoperation rate: We do not think it is feasible to reach this level. We have a very large transmission system with most legacy design being DCB line protection with power line carrier. Changing the scheme to more secure design would require an extreme, large capital investment. Improving existing schemes, replacing electromechanical relays, improving relay settings will not get us near 8% misops. Our view would be improving our misoperations' rate by reasonable improvements to the installed protection.
- SPP RE indicated that a subset of the SPP SPCWG looks at submitted misoperations. As a member of SPP, I was not aware of that review and have never received any feedback. Does SPP, through any work group or task force, ever provide feedback to the reporting TO?
- 8% metric - possibly no impact. If you don't have very many Operations, a single Misoperation is not statistically valid for making broad assumptions and courses of action.
- A single line operation in which relaying on both ends operated correctly, does this count as one or two operations?
- I understand that the 8% misoperations rate mentioned earlier is a NERC target as a whole. Each entity is not created equal, and if in the future someone where to try to use this metric to measure a specific entity's performance it would be inappropriate. My utility is a municipal utility with only 16 miles of BES transmission lines. We have very few BES operations in general. Each misoperation that we do experience drastically increases our percentage to much greater than 8%.
- If the example being discuss has multiple/different owners on the other end of the line, what is the expectation for reporting?
- Why are circuit miles in addition to voltage level not a metric for reporting misoperations? It appears this would help level the playing field for small entities that are reporting.
- In an effort to identify risk, is the data being submitted via MIDAS sufficient to determine trends between voltage level, cause and load loss?
- While a ratio of misoperations to operations may have been an attempt to normalize a metric, it overlooks the fact that these measures cannot capture "what could have been". There are so many instances of a relay responding correctly by not tripping that are never counted or measured. That goes to the point - be careful about the conclusions you draw from this so-called "normalized" data.
- Two additional thoughts relative to the communications cause code. (1) an entity with very few failures due to communication failures may not use communications (DCB) at lower voltage, while others do. This skews a comparison between entities; (2) there is no differentiation between power line carrier communications vs fiber optic vs radio carrier, etc. In addition, the implementation of continuous communications monitoring for PLC is pretty scarce (unless it also supports POTT schemes with a guard tone), but there is almost always continuous channel monitoring of fiber optic systems. As a result, communication failures on fiber optic systems are likely to be lower as problems are more quickly detected and then rectified. Again, this goes to stratification and granularity of the reported data.

- A single line operation in which relaying on both ends operated correctly, does this count as one or two operations?

VI. Parking Lot Items

1. Why circuit miles not a metric? May level playing field for smaller entities.
2. Communication cause code:
    a. Entity with few failures due to communication may not use DCB at lower voltage
    b. No difference between power line communication vs fiber optic vs radio

VII. Conclusions

- Create an action plan to meet the proposed performance metric (8%)
- Create a Misoperations Resource Library
- Host another Misoperations Summit
- Evaluate feedback and parking lot items for future discussions

VIII. If it is decided to hold another event of this sort, what suggestions do you have for the next Misoperations Summit?

- Sharing Misoperation data among industry so we can learn from each other.
    - Best Practice Sharing from utilities who have made impactful progress in reducing Misoperations
    - Target a few specific cause codes and work through recommendations/results
    - Presentations from individual entities
    - Share lessons learned in specific areas such as long, short, medium line faults
    - Comparisons with other REs
- More guidance on how to categorize Misoperations.
- Send questions in advance so participants can prepare prior to the meeting
- Few minutes to discuss what SMEs feel are issues or problems or gray areas with their own application of Misops analysis. Some participants seemed to what that direction.
- Have utilities submit operations for review.

IX. Action Items

- Further explore benefits of socialized reporting.
- Lower bar but not necessarily 8% (8% NERC/ ERO goal, not individual entity).
- Small entity/ BES system impact.