How to Build a Successful Corrective Action Plan

Curtis Sanden, Southern California Edison
Topics

• What’s in it for me?
• Misoperation Investigation Process
• PRC-004 Definition of a Corrective Action Plan
• How to Develop a Corrective Action Plan
• Case Study – SCE Misoperation and CAP
• Interactive Review of Actual CAPs – Good and Bad
• Questions
• Best Practices
What’s in it for me?
What’s in it for me?

• Hopefully prevent repeat misoperations due to similar causes

• Ensure the reliability of your electric grid

• Efforts are underway to effect a nationwide misoperation rate of 8 percent by 2020.
  – The WECC Misoperation Workshop and Reduction Strategy are Western Interconnection efforts to contribute to the reduction.
Misoperation Identification

• You can’t create an effective Corrective Action Plan if you can’t correctly identify the root cause of the misoperation

  I/O module fail? →

  CT/VT fail? →

  DC fail? →

  As left personnel fail? →
Misoperation Investigation

- Misoperation investigations should involve multiple organizations
  - Operations
  - Protection
  - Telecom
  - Test
  - Maintenance
- Important to have all groups acting from the start so that data isn’t lost or corrupted
Misoperation Investigation Process

PROTECTION SYSTEM MISOPERATION INVESTIGATION PROCESS FLOW CHART

1. Send notification of BES relay operation
   - Fault indicated?
     - Yes: Go to step 2
     - No: Go to step 4

2. Confirm correctness of operation
   - Operation correct?
     - Yes: Go to step 3
     - No: Go to step 5

3. Document findings in Relay Event Tracking Database
   - End – Go to WECC/NERC reporting process

4. Confirm with Misop Investigation Team that investigation is starting

5. Investigate for Incorrect Settings, Logic Errors, Design Errors, or Other Explainable engineering-related cause
   - Evidence of Incorrect Settings, Logic Errors, Design Errors, or Other Explainable engineering-related cause?
     - Yes: Inform Misop Investigation Team of findings and develop Corrective Action Plan (CAP)
     - No: Go to step 7

6. Investigate for Incorrect Settings, Logic Errors, Design Errors, or Other Explainable engineering-related cause
   - Evidence of Incorrect Settings, Logic Errors, Design Errors, or Other Explainable engineering-related cause?
     - Yes: Go to step 11
     - No: Go to step 12

7. Assess misop investigation findings and brief management

8. Investigate for Communication Failures or Other Explainable communication-related cause
   - Evidence of Communication Failures or Other Explainable communication-related cause?
     - Yes: Go to step 13
     - No: Go to step 6

9. Inform Misop Investigation Team of findings and develop Corrective Action Plan (CAP)

10. Investigate for Communication Failures or Other Explainable communication-related cause
    - Evidence of Communication Failures or Other Explainable communication-related cause?
      - Yes: Inform Misop Investigation Team of findings and develop Corrective Action Plan (CAP)
      - No: Go to step 10

11. Investigate for AC or DC Systems issues, As-Left Personnel Errors, Relay Failures/Malfunctions, or Other Explainable equipment-related cause
    - Evidence of AC or DC Systems issues, As-Left Personnel Errors, Relay Failures/Malfunctions, or Other Explainable equipment-related cause?
      - Yes: Go to step 13
      - No: Go to step 12

12. Inform Misop Investigation Team of findings and develop Corrective Action Plan (CAP)

13. Inform Misop Investigation Team of “no SC&M-related cause found” conclusion

14. Convene Misoperation Investigation Oversight Team
   - Additional investigation warranted?
     - Yes: Go to step 15
     - No: Go to step 8

15. Convene Misoperation Investigation Oversight Team
   - Evidence of Communication Failures or Other Explainable communication-related cause?
     - Yes: Go to step 10
     - No: Go to step 9

16. Convene Misoperation Investigation Oversight Team
   - Evidence of Incorrect Settings, Logic Errors, Design Errors, or Other Explainable engineering-related cause?
     - Yes: Go to step 7
     - No: Go to step 6

- Formally declare misop cause as “Unknown/Unexplainable”

Assess misop investigation findings and brief management

Inform Misop Investigation Team of “no communication-related cause found” conclusion

Inform Misop Investigation Team of findings and develop Corrective Action Plan (CAP)

Convene Misoperation Investigation Oversight Team

Inform Misop Investigation Team of “no SC&M-related cause found” conclusion

Convene Misoperation Investigation Oversight Team
Corrective Action Plan Description

• What is required
  – Description of what actions are planned
    • *Not only for the scheme that misoperated, but for all other similar installations*
  – Date of completion
    • Target Date
    • Actual Date
  – Quarterly Status updates
    • Analysis – In progress
    • Analysis – Completed
    • Corrective Action – In progress
    • Corrective Action – Completed
    • Declaration Made – No corrective actions
## Corrective Action Plan Description

- MIDAS Report Form

<table>
<thead>
<tr>
<th>Analysis and Corrective Action Status (select from drop down)</th>
<th>Corrective Action Plan</th>
<th>Corrective Action Plan Target Completion Date (MM/DD/YYYY)</th>
<th>Corrective Action Plan Actual Completion Date (MM/DD/YYYY)</th>
</tr>
</thead>
</table>
| Corrective Action - In Progress                            | 2018Q1 Update: CAP in progress.  
2017Q4 Update: CAP in progress. RTDS testing for Antelope-Vincent complete. Pending relay setting installation.  
2017Q2 Update: CAP in progress  
2017Q1 Update: Part of the corrective action plan was completed in March when Protection Engineering worked with SEL to model the event in RTDS.  
A full analysis is expected in May 2017 to determine further investigate necessary CAPs.  
2016Q4 CAP: The first step in the corrective action is to perform RTDS testing to further understand the cause for the Vincent relay not... | 12/31/2018 |
Corrective Action Plan Deadlines

- Per PRC-004
  - A Corrective Action Plan shall be developed within 60 calendar days after the “cause of the misoperation” is identified
    - Note that this is 60 days after the cause is determined, not 60 days after the event
    - Entities have 120 calendar days after the event to identify if it’s protection system components caused a misoperation
      - For major paths or RASs within WECC, this time is reduced to 20 business days
    - If the cause of the misoperation is still unknown 120 calendar days after the event, you must continue to investigate the cause of the misoperation for at least two consecutive calendar quarters
    - Also, the 60 days is to develop, not necessarily implement, the Corrective Action Plan
Relay Inventory

• Entities must have an accurate inventory of all protective schemes and devices
  – Manufacturer
  – Part number
  – Serial number
  – Voltage level
• Must have the ability to query similar schemes/devices as your misoperation
• SCE uses SAP for querying relays
  – Every relay has a SAP number
• SCE uses ASPEN for querying settings
Corrective Action Plan Development

• The “Event Description” and the “Corrective Action Plan” are compliments of one another –
  – The “Event Description” describes the problem or reason for the misoperation
  – The “Corrective Action Plan” describes the solution to avoid a repeat of the misoperation

• Similar to the “Event Description”, the “Corrective Action Plan” is usually a narrative typically longer than one sentence (but less than ½ page) describing the actions required to mitigate the problem
Corrective Action Plan Development

• Clearly define the solution or fix for the misoperation

• Create both short-term and long-term solutions if needed, based on severity of repeat events or time constraints

• Create a list of similar composite protective schemes and/or settings/design/logic

• Prioritize list based on impact for a similar misoperation
  – High impact stations
  – Voltage level
  – Critical transmission paths
  – Highest potential for load dropping
  – Sensitive customer load/generation
Corrective Action Plan Development

• Develop a project or program to apply the solution to all other similar schemes
  – Develop a budget
  – Define all effected stakeholders/resources to execute the plan

• Develop a schedule
  – Adjust timelines to accommodate other workload and resources
  – Combine with routine maintenance or project work
  – Combine or prioritize with other Corrective Action Plans or manufacturer service bulletin upgrade projects
  – It’s OK to have a target completion date of 1-2 years or more
  – Report status or changes to your Regional Entity on a quarterly basis
Corrective Action Plan Success Factors

• Involve management in the creation and tracking of your Corrective Action Plans to set priorities and secure resources

• Assign clear accountability/responsibility for Corrective Action Plan tasks

• Create a database for your Corrective Action Plans

• Meet on a regular basis with affected stakeholders to discuss current and next steps
## Misoperation Database

### Events Data Entry

<table>
<thead>
<tr>
<th>Event ID:</th>
<th>10424</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision ID:</td>
<td>0.1</td>
</tr>
<tr>
<td>Date of Approval</td>
<td></td>
</tr>
<tr>
<td>Protection Engineer:</td>
<td>Kiet Tran</td>
</tr>
<tr>
<td>Approver:</td>
<td>Edward Wong</td>
</tr>
<tr>
<td>Notes:</td>
<td>Vincent Sub 500 kV CB 852 tripped during remote fault on the Mira Loma-Vincent Line</td>
</tr>
<tr>
<td>Event Date:</td>
<td>4/26/2018</td>
</tr>
<tr>
<td>Event Time:</td>
<td>17:11</td>
</tr>
<tr>
<td>GCC Log Entry:</td>
<td>1711 Mira Loma-Vincent 500 kV Line relayed, fault indicated with numerous DFRs initiating throughout the SCE system. 220 kV RMR Capacitors inserted at Laguna Bell Sub momentarily and at Antelope Sub. Devers Sub No. 5 500 kV MSC inserted momentarily. Vincent Sub 500 kV CB 852 tripped. System frequency to 59.847 Hz momentarily and normal in eight minutes when approximately 800 MW QF generation was lost.</td>
</tr>
<tr>
<td>Fault Type:</td>
<td>None</td>
</tr>
<tr>
<td>Time to Clear (cycles):</td>
<td>0</td>
</tr>
<tr>
<td>Event Description:</td>
<td>Vincent Sub 500 kV CB 852 tripped during remote fault on the Mira Loma-Vincent Line. BFH and BFL 4.0ms signal into C60 relay, possibly caused by transient signal from Mira Loma-Vincent shunt cap breakers opening during B-C fault on the line, resulting in C60 relay operating as designed and sending retrip signal to CB852.</td>
</tr>
<tr>
<td>Restoration Method:</td>
<td>Operator Action</td>
</tr>
<tr>
<td>Equipment Removed from Service:</td>
<td>CB 852</td>
</tr>
<tr>
<td>Protection Systems / Misoperating components:</td>
<td>C60 relay</td>
</tr>
</tbody>
</table>

### Approval

- Facility Name: VINCENT
- Voltage, kV: 500
- Equipment Type: Line
- Equipment Name: ANTELOPE-VINCENT NO.1
- WECC Path: BES: ✓ InterTie: GenTie: |
- Relay Model: |
- Protection Scheme: Breaker Failure
- Communication System Type: No Communications
- Communication System Option: Add Relay: Model: C60 Relay Technology: Microprocessor Relay Manufacturer: GE IED
- Report Relay To MIDAS/NATF: C60
- Misoperation Category: Unnecessary Trip - During Fault
- Cause of Misoperation: Other/Explainable
- Misoperation Sub Cause Code (MIDAS): |
- Misoperation Sub Cause Code (NATF): |
- Communication Sub Cause Code: |
- CAP Target Date: |
- CAP Actual Date: |
- Corrective Action Status: Corrective Action - In Progress
- Corrective Action Plan: Change BFL and BFH input contact debounce timers from 2.0ms (factory default) to 16.0ms to better filter transient noise.
| Event Date: | 4/26/2018 |
| Event Time: | 17:11 |
| Event Description: | Vincent Sub 500 kV CB 852 tripped during remote fault on the Mira Loma-Vincent Line. BFH and BFL 4.0ms signal into C60 relay, possibly caused by transient signal from Mira Loma-Vincent shunt cap breakers opening during D-C fault on the line, resulting in C60 relay operating as designed and sending retrip signal to CB852. |
| Fault Type: | None |
| Notes: | Vincent Sub 500 kV CB 852 tripped during remote fault on the Mira Loma-Vincent Line |

**Corrective Action Plan:**

Change BFL and BFH input contact debounce timers from 2.0ms (factory default) to 16.0ms to better filter transient noise.
Corrective Action Plan

- Plan document with detailed instructions on how to apply the corrective action
- Contains a list of all effected locations
- Includes roles & responsibilities and schedule

**GE UR Changing Debounce Time - Draft**

- **Types of Equipment**: GE UR Relays
- **Issue Date**: Revised: none  
  Original Issue: TBD
- **Unusual Occurrence**: BFL Picks Up in Error
- **Most Likely Cause**: Positive DC ground causing induced voltage to pickup BFL
- **Recommendation**: Increase Debounce Time from 2ms to 16ms.
- **Safety**:

**Purpose/Background:**
Four (4) separate events have occurred where four (4) individual 500kV breakers have opened unexpectedly ("Uncommanded CB re-trip"). These occurrences have been researched and recreated reliably. This job aid serves to mitigate another event until the final solution is implemented.

**When to Use:**
If ALL of the following is applicable:
- 500kV Stations
- Station has GE C60’s with BFL/BFH inputs
- Work is occurring or will be occurring where it could disturb secondary cabling, leading to a potential ground on the station DC bus.
- With the concurrence of the responsible protection engineer, change the debounce time from 2ms to 16ms.

As of date of this job aid, no other station configurations has been identified as needing this modification. While there is no identified downside to adding debounce time at other station configuration, it has been decided by TS&S, PE and SC&M management that changing C60’s arbitrarily is not prudent. More testing and a final repair solution is forthcoming.
Corrective Action Plan Tracking

Misop Analysis and Corrective Action Plan Status Meeting

**Date:** May 29, 2018  
**Time:** 2:00PM – 3:00PM  
**Location:** PIV1, Rm 228  
**Prepared by:** Jet Rodriguez, PAX 61548  
**Required:** Jeff Shiles, Neil Stone, S. Jet Rodriguez, Joel Karzen, Robert Lloyd  
**Optional:** Brad Ambrose

### Misoperation Analysis and Corrective Action Plans

<table>
<thead>
<tr>
<th>Item #</th>
<th>Line Name (WECC Reporting Ctr.)</th>
<th>Misop Date</th>
<th>WECC Notice Due</th>
<th>Analysis/RET Due Complete</th>
<th>Next Step Date</th>
<th>CAP/Next Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Vincent Sub 500kV CB 852</td>
<td>4/20/18</td>
<td>8/17/18 (Q2 2018)</td>
<td>Yes/No</td>
<td>TBD</td>
<td>Same CAP as Serrano 500kV CB 732 misop on 9/21/17.</td>
</tr>
<tr>
<td>16</td>
<td>El Nido-La Fresca 220kV</td>
<td>5/1/18</td>
<td>8/17/18 (Q2 2018)</td>
<td>Yes/Yes</td>
<td>N/A</td>
<td>There was telecom work done at El Nido substation that left the communication synchronizing timing source misconfigured that led to the misoperation. The introduced channel asymmetry was beyond what the relay can accommodate. Equipment was removed from service initially right after the operation of the relay. However, based on telecom groups confirmation of completion of correcting the misconfigurations, relay was returned into service.</td>
</tr>
<tr>
<td>15</td>
<td>Control-Silver Peak C 55kV</td>
<td>5/12/18</td>
<td>8/17/18 (Q2 2018)</td>
<td>Yes/Yes</td>
<td>5/16/18</td>
<td>Misoperation due to as-left personnel error. The AS-Left File in ASPEN, dated 9-15-15, has the correct settings. This relay was used for the in-service of Zack substation when Temporary settings were installed in this relay.</td>
</tr>
</tbody>
</table>

### Deadlines for Data Submission into MIDAS are:

- March 1, for the prior year
- May 30, for Quarter 1, January 1 – March 31
- August 29, for Quarter 2, April 1 – June 30
- November 29, for Quarter 3, July 1 – September 30
- March 1, for Quarter 4, October 1 – December 31
Corrective Action Plan Case Study

• At SCE, we recently had several instances where momentary retrips were sent from a C60 breaker failure relay which inadvertently opened the respective circuit breaker
• The resulting misoperation investigations found that momentary spikes in the DC system occurred with work going on at the substation
• DC spikes momentarily close the relay output contacts energizing the BFI inputs on the C60 relay

• If the CB is closed, and the BFI input is energized for even a brief moment, the retrip output will close with no delay, sending a trip to the CB
Corrective Action Plan Case Study

• The corrective action taken was planned in two phases
  – Phase 1 - Increase the debounce time on the BFI inputs from the default 2msec to 16msec, which was longer than the observed DC spikes
  – Phase 2 - Investigate the addition of a damping resistor across the C60 input or replacement of I/O modules. Ultimately, the solution to replace the I/O modules was chosen

• Debounce times were changed on every C60 applied at the same voltage level at those stations where the inadvertent retrips had occurred

• No work involving cable pulling was to be performed at other similar stations until the debounce timers were changed at those locations
Corrective Action Plan Case Study

• A list of all C60 locations was generated, and prioritized by station voltage level and current or upcoming work at the station
• A Phase 1 initiative was started to change the debounce timers following the prioritized list
• A Phase 2 initiative will soon roll out to swap out I/O modules and incorporate changing the debounce timers, again based on the prioritized list
• The target completion dates for both phases were selected based on availability of manpower and outages
Corrective Action Plans

The Good, the Bad, and the Ugly
Prior corrective action for similar misoperation called for relay settings changes at Sta A to separate PT and OB-Key on both primary 1 and 2 relays. Sta B settings changes were to add OB-Key to PT equation on both primary 1 and 2 relays. Settings for Sta A primary 2 relay were never applied by field, resulting in a standing TRIP to Sta B breaker, preventing closing. Setting change at Sta A was to separate PT and OB-Key into individual Mirrored Bits: TMB1A = TRIP + TRIP87 + KEY; TMB3A = SV1T (open breaker detection). The missed settings at Sta A in primary 2 relay were applied immediately after it was discovered they had not been changed previously. Dispatch was able to close Sta B CB 1 once settings were all applied.
CAP Example 1: Does this sound adequate?

Insert poll
CAP Example 1: Answer

Yes, this plan addresses in detail what actions were taken to address the problem. It actually restates some of the information stated in the “Event Description”. It also appears as if the previous Corrective Action Plan was either not yet complete or the setting change at Station A was missed.
CAP Example 2: Description

Change zone 3 setting
CAP Example 2: Does this sound adequate?

Insert poll
No, this plan lacks enough detail. It should state what the corrected setting will be set to, and how that will mitigate the problem (i.e. Zone 3 setting decreased from 15 ohms to 10 ohms to avoid overreaching the adjacent Zone 2 at Sta B, etc.).

It also only addresses the corrective action for that one relay, and doesn’t address other relays which may have the same setting overreach. Was this a one-off error or a philosophy change that may be present in other settings?
CAP Example 3: Description

Comm Engineer investigate and correct
CAP Example 3: Does this sound adequate?

Insert poll
CAP Example 3: Answer

No, this plan lacks enough detail. What is the Comm Engineer going to investigate? This is an example of where the different stakeholders need to work together to review the misoperation and decide on what investigation should occur. Afterwards, the corrective action should be clearly stated.

It may be assumed that this Corrective Action Plan is still in the “Analysis – In progress” stage of investigation.
Investigations and troubleshooting by battery charger manufacturer representative revealed the failure of the DC output breaker and the breaker was replaced.
CAP Example 4: Does this sound adequate?

Insert poll
Yes. Even thought the description was brief, it clearly stated the action required to fix the problem. Unless there was a design or manufacturing flaw with an entire product line of breakers, the solution is to simply replace the single failed breaker.
CAP Example 5: Description

SCADA Logic
CAP Example 5: Does this sound adequate?

Insert poll
CAP Example 5: Answer

No, this plan lacks details.
Questions

Curtis Sanden, Southern California Edison

curtis.sanden@sce.com  626.622.4582
Corrective Action Plan Best Practices

• Engage all stakeholders in both the investigation and corrective action process
• Easily searchable relay inventory database
• Consider creating both long-term and short-term solutions
• Management engagement in developing and tracking CAPs
• Periodic CAP meetings with all stakeholders