

October 8, 2014

Ms. Beth Krogel Roads
Indiana Utility Regulatory Commission
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Indianapolis, IN 46204
bkroads@urc.in.gov

Dear Ms. Roads:

We at O'Neill Management Consulting are pleased to hereby offer our independent review of IPL's report, "Root Cause Analysis for 26 S. Meridian Street Network Event on August 13, 2014". Beginning with our site visit on August 26-27, 2014, and continuing by telephone and e-mail through last week, we have observed IPL's efforts to develop the root cause analysis report, commenting at various points on the process employed and the content of the report in draft. The final report remains the product of IPL itself, and we are not in any sense co-authors.

Our role in the process

An aspect of our role in this process was revealed during the onsite meeting on August 26, when we began the meeting, after some initial pleasantries, by reading the following quote from the Executive Summary of our December 13, 2011 report, "Independent Assessment of Indianapolis Power & Light's Downtown Underground Network" (of which report we were the sole authors):

An analogy can be made to modes of transport such as driving a car, riding in an airplane, or walking the sidewalks. In those modes, the risk is managed by a process that, when it works well, investigates every significant instance of equipment or operator failure, tracing its root cause, and then mandating appropriate remedial action, which might be a traffic citation, an equipment recall, or a mandated change in the design of cars, airplanes, or sidewalks and crossings. As new modes of failure are discovered, new remedies are put in place.

Our findings, detailed below, indicate that, based on our examination of the recent and past incidents and our audit of the current system condition and practices in comparison to those of other utilities, there is an **immediate need to improve the process** by which IPL finds, documents, and remediates failures in its electrical system in downtown Indianapolis. The recommendations contained in this report, if acted upon, can further reduce the risk of service interruption, collateral damage, and possible injury associated with the system. (Emphasis retained from original)

We went on in that initial meeting on August 26 to comment on IPL's root cause analysis process in this instance, agreeing with IPL's inclusion of such features as a sequence of events, the evidence from various sources (including IPL's automatic recording and archiving system as well as videos taken by the public at the time), and what was known about the equipment at that location. At that time we emphasized the need for a thorough examination of the inspection and maintenance records, and also a tabulation of the known facts. We also offered some thoughts about various alternative modes of failure that might have led to the event. On August 27, my

colleague, Charlie Fijnvandraat, escorted by IPL representatives, visited the 26 S. Meridian Street vault and also the Gardner Lane Substation.

At that initial visit and subsequently we noted that while the term “root cause analysis” would seem to be focused on what caused the initial equipment failure, it is important in any such study to also analyze the implications of actions taken during the event that might have mitigated or exacerbated the implications of the initial failure, e.g., the actions of the system operators at the control center as well as the IPL emergency response team at 26 S. Meridian Street. The IPL RCA team acknowledged that insight and incorporated it into the outline of their report.

As IPL’s report developed in draft form, we reviewed the specific recommendations and commented on how they might be more clearly communicated and be more fully responsive to the opportunities for improvement.

We now turn to our opinion on the process and the report.

Summary opinion

Overall, we find the report and the process employed to be generally consistent with industry practice of root cause analysis (RCA) for comparable events. In the following paragraphs we raise specific points worth noting.¹

The team and the process

IPL assembled a team for this root cause analysis, listed on page 9 of the report. We noted at the meeting on August 26 that it seemed that was the first full meeting of the team (and Barry Feldman, Director of Asset Management, was not at that meeting; Senior Vice President Joe Bentley participated at one point by phone, which was appropriate for his role). In general, we had a sense that this was an ad hoc approach as opposed to a part of a fully functional root cause analysis function within asset management, but the latter, larger question was not within the scope of our review. We are content to say that the team assembled for this event’s RCA was appropriate and competent to do so.

We also noted at the meeting on August 26 that the examination of the inspection and maintenance records was underemphasized. The IPL team acknowledged that was important and would be examined further. Some attempts were made at that time to assemble more detail from those records, but with limited success. We would have more to say about that as the process went on.

¹ It is important to keep such comments within the context of the event. We have experience, for example, in working with NERC on its failure analysis process, and are also familiar with such processes in the nuclear industry. In each case, the first step in the RCA is to determine the level of event severity and therefore the level of RCA appropriate for the event. In this initial ‘triage’ it is appropriate to ask questions such as, “How might this event be a harbinger of other events that could be avoided or mitigated?” or “How severe *might be* the consequences of such an event, *whether or not* the consequences were severe in the particular event under analysis?”

The proximate cause of the event

We were pleased to see that IPL reached out to Eaton Corporation for assistance in analyzing the failure of the equipment, since they are the corporation that inherited through acquisition the legacy of the Westinghouse equipment that failed and are also one of two leading manufacturers of new and replacement network protectors. The Eaton representative was able to cite recent examples of similar failures elsewhere in the industry and therefore a likely cause for the failure, namely, the dielectric breakdown (failure to insulate) of a bus support insulator, probably the one on the floor of the C phase bus support.

In examining the other known facts, especially the action of the various fuses and circuit breaker (network protector) relays and the pattern of damage, we were concerned that the Eaton explanation might require extra assumptions of extraordinary bridging of components in order to explain the known facts, and we were therefore pleased to see that IPL included in its report another possible scenario of the proximate cause, while acknowledging the value of the manufacturer's experience with similar incidents.

At one point a question was raised as to the relatedness of the capacitor bank failure in the Gardner Lane substation, one mile away from 26 S. Meridian Street. There was a small (.3 MVAR) spike at 1:03 PM², almost a half-hour before the 1:25 PM fault on that capacitor bank and the presumed start of the event at the 26 S. Meridian Street vault. At this point, there is no clear direction of causality between these two events (the cap bank failure and the network protector failure), and it is unlikely that any further analysis can resolve this indeterminacy. We feel that even if the failure of the cap bank preceded the failure in the network protector, it was the latter that is the proximate cause of the 'event' at 26 S. Meridian Street, since every other protector connected to that Gardner Lane substation bus would have seen the same spike and did not fail.

As it turns out, no matter which cause was the actual precipitant of the event, the recommended plan of replacing all of the 480-volt network protectors will address the problem, as well as addressing the OSHA-required arc flash issue for 480-volt systems. In addition, the other eight recommendations are not affected by which cause is most likely.

The evidence and its preservation

One of the most important contributions to a successful RCA is the preservation of relevant evidence that can be used to analyze the event and its implications. This includes sequestering as much as practicable any failed equipment and also any records associated with the operation and maintenance of the equipment in question. In this regard, the results were mixed. As one would hope, IPL did not disassemble the UG651 protector before the Eaton team was there to observe it. Photographs were taken before, during, and after the inspection. Also, IPL's PI Historian system did a good job of recording the energy management system events at the substation and feeder level, and the team used that system to determine many key facts.

² We also note that the SCADA telemetry errors also occurred closer to 1PM than the assumed 1:25 PM start of the event at 26 S. Meridian Street.

On the other hand, the failure of the network protector SCADA system was a disappointment to all concerned, and is appropriately addressed with a recommendation to develop a plan to examine the frequency and extent of telemetry errors in that system, and ways to avoid loss of that data in a catastrophic event. Similarly, we were disappointed that the records of inspection and maintenance on the UG651 network protector and the others in the same four-bay vault were not more useful to the team's inquiry. Some of the problems in those records were noted by us in an e-mail to the team, namely,

- A lack of paper records for those inspections previously done prior to electronic forms
- EMPAC work order descriptions for repairs that do not describe the issue found or follow up work required (pumping protector, relays)
- Completed EMPAC work orders that have zero hours charged (or less than has historically been charged for similar activities)
- EMPAC work order descriptions that mention pictures were taken but which cannot now be found
- IVARA data that captures one or two responses of a multi-question inspection form
- IVARA quantitative data that is shown as done but no values are recorded

Again, we are pleased to see that the recommendations include one that specifically addresses the need to improve the quality of the inspection and maintenance records. We note, as well, that this issue was addressed in our December 13, 2011 report, and that some of the inspections in question were completed shortly after the implementation plan for that report was developed in January, 2012, so we can appreciate that the asset management procedures may have improved somewhat over the last two and a half years, although the scope of this report would not have included a review of that assumption.

The response to the event

As noted above, we consider response to an equipment failure to be as important in a root cause analysis as the proximate cause of the failure itself. Often we find in the industry that events of the highest severity are the result of a 'perfect storm' of an equipment failure, combined with a relay or protection scheme failure, exacerbated by a human error in the response to the event. In this case, we are pleased to report that this event was only a two-strike event³, in that the emergency response was effective in mitigating the potential implications of the equipment failure.

We hasten to add, however, that were it not for quick, smart decision-making by the IPL incident team, the event may have had more serious consequences, and we note that one of the key players in that event has recently retired, raising an issue of whether future events will have similarly good outcomes. IPL has included a recommendation that addresses this, and has responded to a separate IURC request to address its staffing for

³ The second 'strike' was that the failure either originated in or spread to an 'unprotected zone' between the network transformer and the transformer-side contacts of the fault interrupting mechanism of the network protector. So, while there was not a relay failure as such, there was, in a sense, a failure of the protection scheme.

the downtown underground network. We would urge the IURC and IPL to continue to monitor IPL's progress in this critical area.

We also noted that there is no written emergency response plan⁴, and that while it may have seemed unnecessary to have such a plan when a small group of people who have worked together for years would be the response team, we feel, and the IPL team agreed, that in these modern times of formal emergency response procedures at all levels of industry and government, and especially in the light of known and possible transitions in staff, the time has come to develop a written plan and to drill it and communicate it with all concerned, including the Indianapolis Fire Department, the IURC, and other concerned parties.

We digress briefly to make a relevant analogy. In the area of natural gas leaks, with which we also have extensive experience, the industry has long recognized that a two-pronged approach is appropriate, in terms of 1) programs to reduce the number and severity of leaks, e.g., replacing leak-prone pipe, and 2) programs to ensure timely and appropriate finding of and response to leaks, e.g., within 30 minutes. We might add that a third ancillary component is public education about what to do about gas odors and marked-off areas, with obvious analogous opportunities to avoid smoking manholes or vaults. In fact, when it comes to avoiding injury to the public, the avoidance of the equipment failure may well be considered as secondary to the urgency attached to emergency response.

Finally, in this regard, we note that the failure of the SCADA telemetry removed an important weapon in IPL's potential response to the event, since had the SCADA been operational, the system operator could have by remote control opened the other three network protectors, which, in combination with opening the UG651 feeder breaker, would have de-energized the secondary bus, thus reducing a key source of arcing fault energy. This underscores the importance of the recommendation to investigate and resolve the occurrence of telemetry errors on the network protector SCADA system.

The findings, recommendations, and action plan

As noted above, we must accept a certain degree of indeterminacy in the findings of root cause, while at the same time emphasizing the need for improvements, as noted in the recommendations, in certain systems and processes that might have provided more and better information about the proximate root cause of this incident.

⁴ See the first sentence of section 5.0 of the IPL RCA report. We are told that IPL has an extensive Emergency Response Plan ("Storm Plan") for the system as a whole, but the unique nature of the downtown underground network is not specifically addressed there. We would advise, then, that recommendation 2, which currently reads "Develop a formal written Network Event Response Plan" should be understood to mean "develop, as part of the company's Emergency Response Plan, specific written procedures for handling the downtown underground network aspects of any emergency, including but not limited to a network incident like the one on August 13, 2014." Moreover, this should include aspects of who would be responsible for what actions under the plan.

The first recommendation addresses the equipment itself with a program of preventive replacement over the next five years. While some in the industry are further along in this process than IPL, others are similarly just beginning their replacement programs to support their overall strategy to comply with OSHA-mandated arc flash worker protection rules. The incidence of this type of failure is sufficiently low as to not require a more accelerated rate of replacement, and in any event the outages required will take some time to schedule.

The other eight recommendations address other aspects of the process, mainly focused on one or another aspect of the response or the root cause analysis process, as in:

- Develop a written emergency response plan; drill it; communicate it
- Develop a mitigation plan, including possible selective replacement of the fluid in 480-volt network transformers with a fire-retardant fluid
- Address the SCADA telemetry errors that impeded emergency response
- Ensure no critical loss of talent in the response team, and ensure IPL's participation in industry forums that can provide up to date information about known problems and strategies for prevention and response
- Improve the ability of the asset management system to provide complete and accurate records of inspection and maintenance

We note that many of the other eight recommendations have language which would not necessarily commit IPL to a plan of action that would address the problems identified. For example, recommendation 5 says to "Conduct a review of all Gateway Vault circuits for communications stability and frequency of telemetry errors." We would prefer to see language in an action plan that would commit IPL to fixing the problems found in such a review. We recognize that all communications systems have some reliability problems, but we would expect that any system which is critical to the safe operation of the system would have sufficient redundancy or reliability to ensure a high degree of communications continuity, and that a communications failure would be something that would be addressed with appropriate urgency.

Similarly, we note:

- Recommendation 4 says to "Develop a mitigation strategy..." but does not say to implement it. (It also makes reference to coordination with Recommendation 7 which does not seem to make sense and is likely a remnant of an earlier draft in which the study of the non-protected zone was a separate recommendation numbered 7).
- Recommendation 7 says that to "Ensure no critical loss of talent..." IPL should "continue to monitor, update, and implement the Company's succession plan for key staff..." yet since we have not seen the succession plan and we know that in any event it has not yet been updated for changes made since the merger with DP&L, we do not see how the "continue to" language addresses the fact that no transition was arranged for the imminent retirement of a key staff person (no candidate selected in advance and given time to shadow the employee before his departure, etc.). Nor do we see any current provision against the possibility that one or more other key staff, many of whom are eligible for retirement at any moment, might leave.
- Recommendation 9 says "Take steps to improve the state of inspection and maintenance records" yet does not ensure that the problems cited above (at the top of page 4 of this letter) would be addressed.

Since the IPL report is final at this point, we would hope that any subsequent action plan would put more ‘teeth’ into the recommendations. The action plan is quite terse at this point. We somewhat understand that the effort to flesh out its details might be dependent to some extent on the IURC’s acceptance of the report and its recommendations. Nevertheless, implementation of the most urgent recommendations should not be delayed, e.g., filling any key positions in the response team and implementing the action plan from the meeting with IFD.

We have appreciated this opportunity to serve the IURC and IPL in reviewing the RCA of the August 13, 2014 network event at 26 S. Meridian Street, and we are confident that if IPL follows through on the recommendations with appropriately actionable plans with the proper urgency and funding where necessary, the citizens of Indianapolis will be able to continue to have confidence in the electrical network system that serves the downtown area.

Sincerely,

A handwritten signature in cursive script that reads "Daniel E. O'Neill".

Daniel E. O’Neill
President and Managing Consultant
O’Neill Management Consulting, LLC

Cc: Joe Bentley, Mike Holtsclaw, IPL
Bob Veneck, IURC, Brad Borum, IURC