Analyzing EMS Outages

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Outages and the Events Analysis Process Overview, Themes, and Lessons Learned

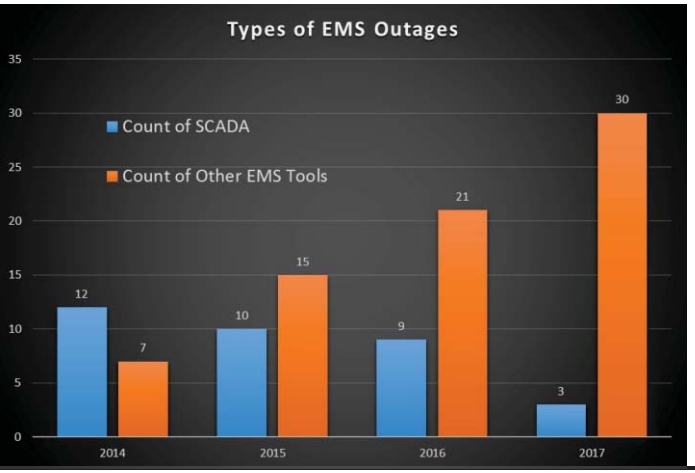
Last year, RF's Events Analysis and Situational Awareness (EASA) team analyzed EMS outages going back to 2014 to better determine the breadth and severity of these events.

Through the Event Analysis Process (EAP) , the Regions analyze these outages, also known as category 1h events, to determine the root cause, contributing causes, and mitigating circumstances. This is done through NERC's Cause Code Assignment Process (CCAP).

The purpose of this article is to share our findings and give you an idea of what we do with the data collected through the EAP.

Last year, RF analyzed 107 new and historical EMS outages to discover trends, lessons learned, and best practices. These events are typically communicated to RF through the EOP-004 process where an entity submits a disturbance report upon the loss of EMS functionality for greater than 30 minutes.

Some of the events submitted involved a complete loss of monitoring and control, while others were an outage of EMS tools and capabilities such as State Estimation, Real-Time Contingency Analysis, or Inter-Control Center Protocol. For more information regarding the types of EMS outages, please see RF's newsletter article on the Operating Committee Reference Document Risks and Mitigations for Losing EMS Functions.



Lessons Learned 2017 (4)

LL20170503	Loss of SCADA Operating and Monitoring Ability	Communications	5/16/2017
LL20170502	Line Frequency Excursion Causes UPS Shutdown and Control Center Evacuation	Communications	5/16/2017
LL20170501	Loss of Monitoring Due to Authentication Software Update	Communications	5/16/2017
LL20170302	Loss of State Estimator due to Propagated Database Values With Invalid Data	Communications	3/14/2017

Lessons Learned 2016 (10)

LL20161202	SCADA System Software Design Flaw Prevented Processing of Alarms and Events	Communications	12/6/2016
LL20161201	Loss of ICCP – Local Control Center Notifications	Communications	12/6/2016
LL20161103	Loss of ICCP due to Database Sizing Issue	Communications	11/1/2016
LL20161102	Failover Configuration Leads to Loss of EMS	Communications	11/1/2016
LL20161101	Redundant Systems May Not Cold-Start Unless Fully Intact to Prevent Dual Primary Operation	Communications	11/1/2016
LL20160701	Unavailability of the Transmission Stability Limits Calculation Application	Communications	7/5/2016
LL20160604	ICCP Communication Failure Due to Firewall Patch Update	Communications	6/14/2016
LL20160603	Loss of Monitoring Capabilities Due to FEP Hardware Malfunction	Communications	6/14/2016
LL20160602	SCADA Failover Event	Communications	6/14/2016
LL20160501	Control Center Loss of SCADA Control and Monitoring Capability	Communications	5/24/2016

Following the submittal of an EOP-004 form, the registered entity typically submits a Brief Report to RF which includes details of the EMS outage. These details include the causes, a sequence of events, and the mitigating circumstances. The EASA team then works with the entity to document the root-cause, contributing causes, and mitigating circumstances.

If an event includes facts and information that may be particularly useful to share with the industry, RF may work with the entity to create a Lessons Learned document. Currently there are over 40 such Lessons Learned documents that are posted on NERC's website with the category "Communications," most regarding category 1h events. The table below show EMS-related Lessons Learned documents from 2017 and 2016.

Types of EMS outage occurrences

RF analyzes the number of EMS outage occurrences, by type. Even though there has been an overall increase in the number of EMS-related outages, a significant trend is that there are less SCADA outages (which involve the loss of monitoring and control). However, there was an increase in State Estimator outages, which could be the result of the following:

- Changing reporting requirements (eliminating the category 2b and creating the category 1h.v events),
- Requirements for Transmission Operators to run Real-Time Assessments introducing new EMS tools and technologies,
- Expanding external models to create visibility overlaps with neighbors, and
- EMS tuning issues where settings needed to be calibrated due to changing dispatches and generation retirements.

Analyzing EMS Outages

Causes of EMS Events

Next, RF looked at the 2014-2017 events to determine if there were trends with the causes. To organize the data, RF developed five general themes to classify each event.

1.) **Software:** Outages due to a software bug or database issue with the EMS. Sometimes software crashes or fails, and the entity works with the vendor (typically GE, Siemens, OSI, or ABB) to repair, patch, or fix the software related concern.

2.) **Data:** Outages due to external data that results in the State Estimator not converging. This could be data that is not accurately modeled, data of poor quality, or a lack of data due to a communications-type issue. These issues are resolved by communicating with neighboring entities to upgrade the external model and reconcile any data errors.

3.) **Loss of Power:** Power outages to a control center or data center that result in the loss of EMS functionality. Mitigating actions include looking at the design and redundancy of power supplies to ensure there is not a single point of failure.

4.) **Maintenance:** Any type of change to the EMS or supporting systems that results in a SCADA, ICCP, or State Estimator outage. These outages are often due to change-management issues.

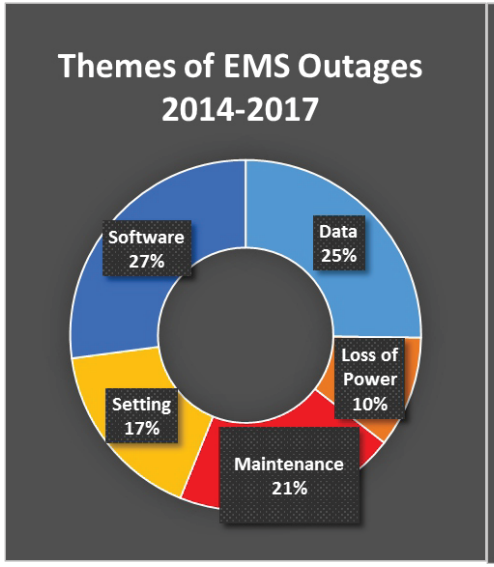
5.) **Settings:** Any type of EMS outage due to less-than-adequate EMS system settings or parameters. Oftentimes settings are adequate upon installation, but due to topology changes or dispatch changes, settings need to be adjusted (tuned/calibrated) to help the State Estimator converge while maintaining a quality solution.

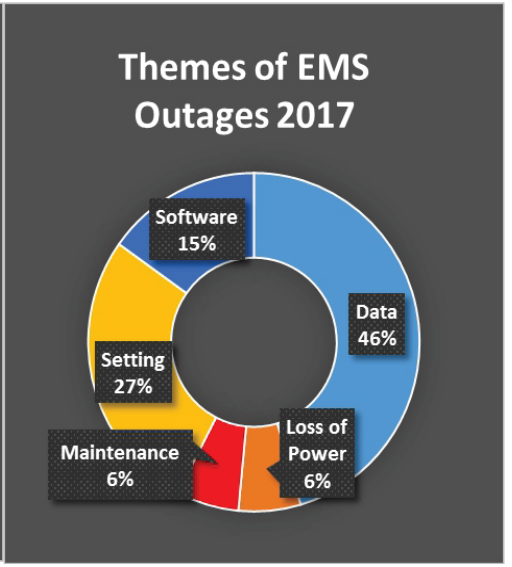
The first pie graph shows the distribution for all the EMS events from 2014, and the second graph shows the 2017 data. In the RF Region, there has been a significant reduction of maintenance and loss of power events.

Based on these events, change-management controls appear to be improving and RF is seeing less instances of outages caused by software patches or changes to the EMS. However, RF has seen an increase in data and settings-related outages. This has caused the increase of State Estimator outages as there are times where the data or settings result in non-convergence.

RF is actively engaged with NERC to write two new Lessons Learned documents covering these issues; further communication will follow when these are posted.

Next, RF looked at the cause-codes that are developed via the CCAP process to determine which codes were coming up most often and when. The cause-codes have





nine general categories (called A-level categories), indicated below.

- A1: Design/Engineering
- A2: Equipment/Material
- A3: Individual Human Performance
- A4: Management/Organization
- A5: Communication
- A6: Training
- A7: Other (External)
- AX: Overall Configuration
- AZ: Information to determine cause less-than-adequate (LTA)

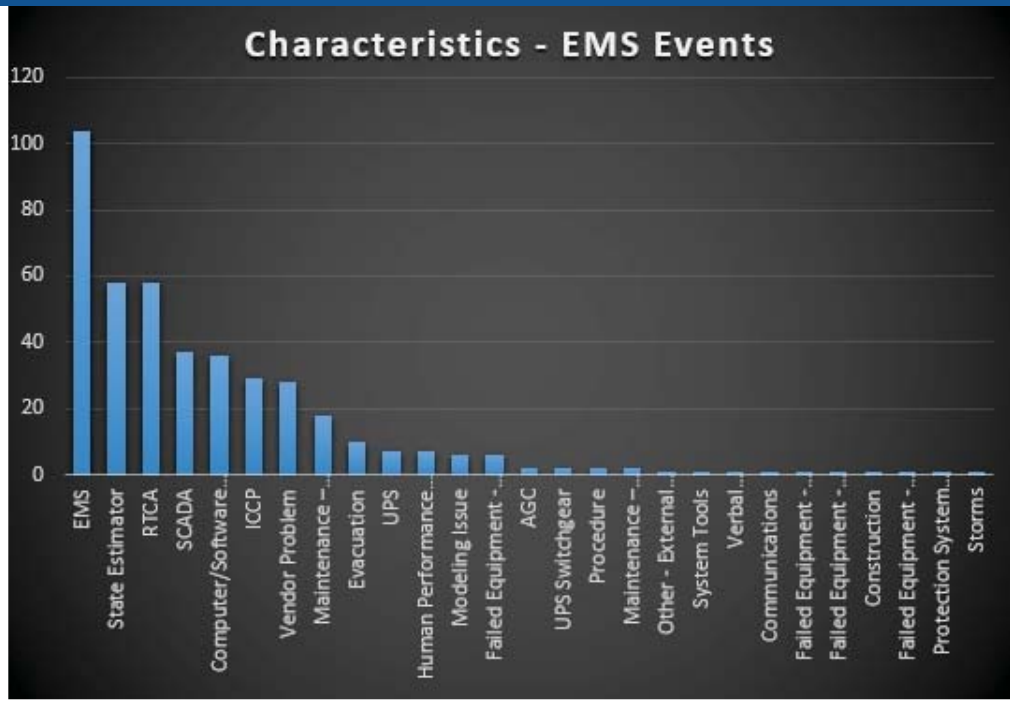
The cause-codes are broken into more detailed categories (called B and C-level categories) for more granular causes. However, RF focused on the A-level causes and how they were mapped to the five categories listed above. This helps determine not only what happened, but why.

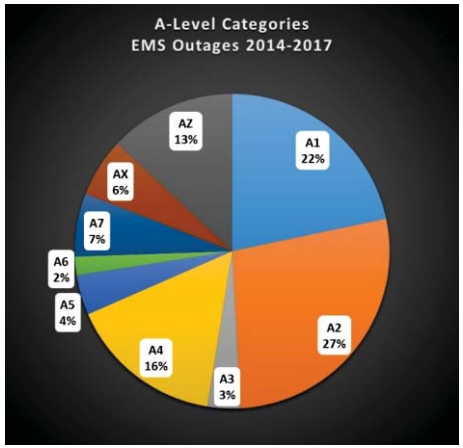
The mitigations can then focus on these contributing causes to reduce the number and duration of EMS occurrences. For example, data issues need to focus on design/engineering while maintenance issues are often attributed to management/organization (specifically change-management, work planning, and job scoping).

Analyzing EMS Outages

From the charts below, almost half of the causes were due to design and equipment. Approximately 13% of the cause-codes were AZ (unknown) where the vendor and entity could not determine a specific root-cause following a review of logs and circumstances. Very few EMS-related outages analyzed 2014-2017 are due to training or communication being LTA.

Finally, RF analyzed the characteristics of the EMS outages. Looking at the chart to the right, the largest characteristics are the natures of occurrence (type) such as EMS, State Estimator, RTCA and SCADA. One interesting characteristic that occurred over a quarter of the time was Vendor Problem. In these cases, the entity flagged some type of vendor issue with the EMS system that contributed to the outage. As NERC collects these events, the data provides the opportunity to give vendor feedback. Vendors are also invited to the annual NERC Monitoring and Situational Awareness Conference held every fall where industry meets and discusses not only EMS-outages, but EMS enhancements, lessons learned, and best practices.





A Codes	A1 Design / Engineering	A2 Equipment / Material	A3 Individual Human Performance	A4 Mgt / Org	A5 Communication	A6 Training	A7 Other	AX Overall Configuration	AZ Information LTA
Data	28	28	1	4	1	1	3	4	10
Software	15	33	1	6	4	4	9	2	18
Loss of Power	15	17	2	12	4	1	6	0	7
Setting	16	7	6	8	3	1	3	14	9
Maintenance	16	29	4	36	5	1	6	5	10

Analyzing this data has been useful as it helps RF in its collaboration with NERC on the EMS Working Group, writing Lessons Learned Documents, and participating in the Monitoring and Situational Awareness Conference.

It allows RF to answer questions on why EMS-related events are happening and work with entities on mitigation.

RF will continue posting documents and publications regarding EMS-outages on our updated website in the Knowledge Center as part of our process for disseminating information regarding the risks and mitigations involving the loss of Situational Awareness.

RF is proud that recent studies have shown EMS run-time to be at 99.99%, and we will continue to analyze the 0.01% of the time these systems are not working as they should.

Note: in the Operating Committee Reference document, NERC uses four categories (Communications, Software, Facility, and Maintenance).