MIDWEST RELIABILITY ORGANIZATION

A Reliable and Secure North American Bulk Power System

Priority risks and areas of focus for MRO in 2022

April 7, 2022

Agenda

- **ERO Risks and MRO Regional Risks**
  - North American-Wide Risks
  - MRO Regional Risks
- **Regional Reliability Risks**
  - Process for Identification and Prioritization
  - MRO Reliability Risk Priorities for 2022
- **Regional Security Risks**
  - MRO SAC Regional Security Risk Assessment (RSRA) Process
  - MRO Security Risk Priorities for 2022
- **CMEP Activities and Risk Analysis**
  - Operations and Planning Standards
  - Critical Infrastructure Protection (CIP) Standards

John Seidel

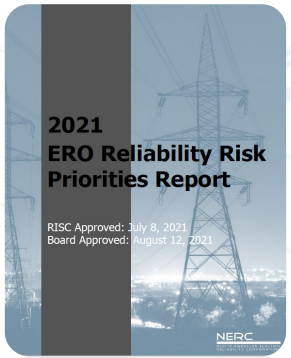
Principal Technical Advisor

MRO 2022 Regional Reliability Risks

North American-Wide Risks

- **The MRO 2022 RRA references several ERO-wide reports that assess North American bulk power system risk:**
  - 2021 ERO Reliability Risk Priorities Report (RISC report)
  - 2021 NERC State of Reliability Report (SOR report)
  - 2021 NERC Long-Term Reliability Assessment (LTRA)
  - NERC/FERC February 2021 Cold Weather Inquiry Report
  - 2022 ERO CMEP Implementation Plan

Risk Groupings from 2021 Biennial RISC Report



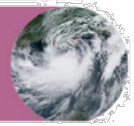
Grid Transformation

A. Bulk Power System Planning
B. Resource Adequacy and Performance
C. Increased Complexity in Protection and Control Systems
D. Situational Awareness Challenges
E. Human Performance and Skilled Workforce
F. Changing Resource Mix

Security Risks

A. Physical
B. Cyber
C. Electromagnetic Pulse

Extreme Natural Events



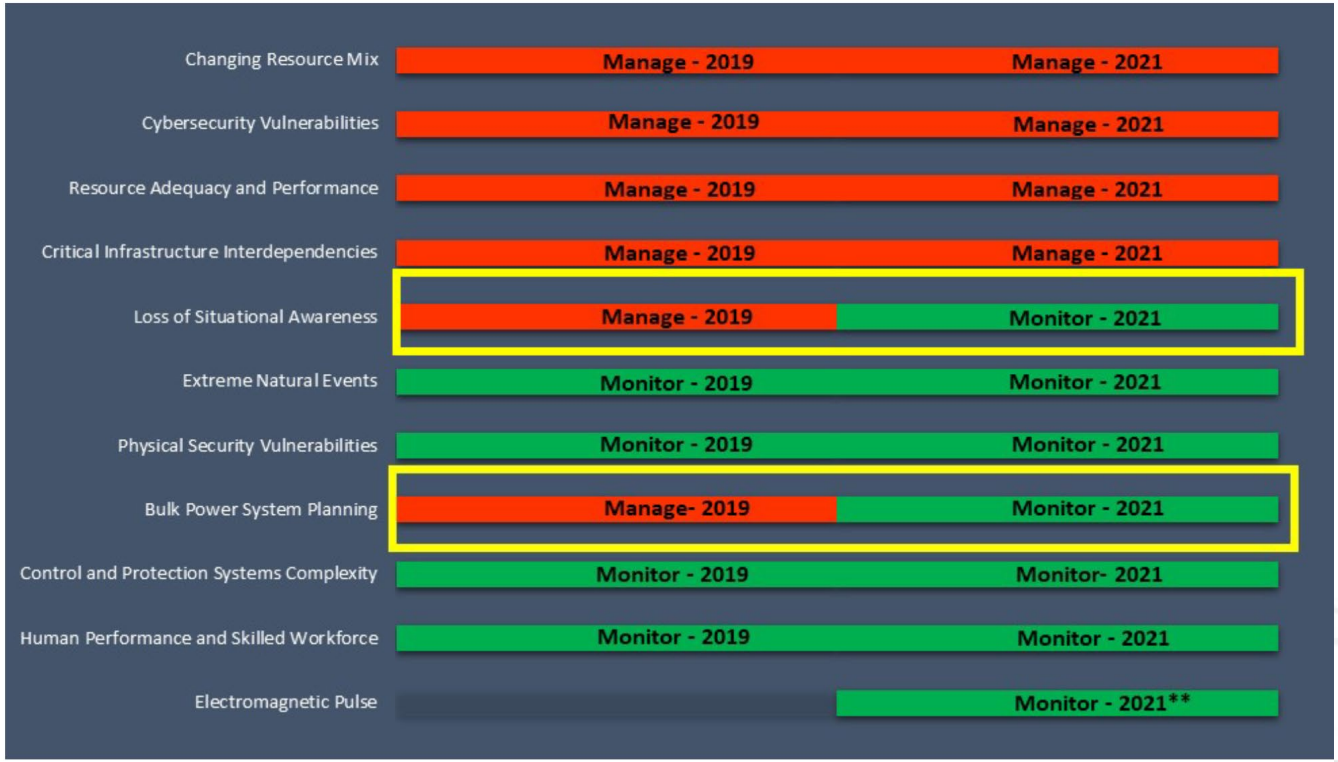
A. Extreme Natural Events, Widespread Impact
   - GMD
B. Other Extreme Natural Events

Critical Infrastructure Interdependencies

A. Communications
B. Water/Wastewater
C. Oil
D. Natural Gas

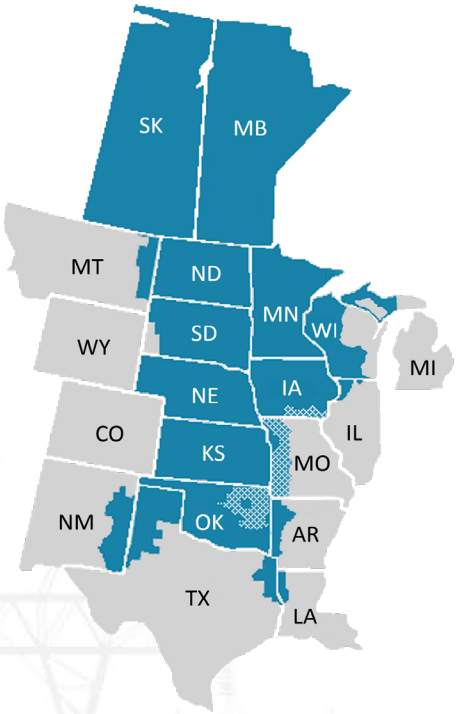
Risks Rankings from 2021 Biennial RISC Report

Manage vs. Monitor - 2021 Biennial RISC Report



Identifying Regional Risks

- **Operations and Planning Risks**
  - Identified from Planning Coordinator assessments and RAPA data collections:
    - Event Analysis, Misoperations Reporting, Energy Emergency Alerts, NERC Alerts, NERC Lessons Learned
- **Physical and Cyber Security Risks**
  - Captured annually in the MRO Regional Security Risk Assessment



Assessing Regional Risk

- **MRO staff and the three MRO advisory councils collaborated to:**
  - Identify risks that may have a higher probability of occurrence and/or impact within the MRO region
  - Assess the resulting risks in terms of impact and likelihood, using the MRO Reliability Risk Matrix

MRO Reliability Risk Matrix - Operations and Planning Reliability Risk Rankings						
Consequence/Impact (C)		Likelihood (L)				
		L1	L2	L3	L4	L5
		Very Unlikely	Unlikely	Possible	Likely	Almost Certain
C5	Severe					
C4	Major			9	2 10	
C3	Moderate		3 4	1		
C2	Minor			8	5 6 7	
C1	Negligible					

	Operations and Planning Risks
1	BPS Modelling Accuracy *
2	Uncertainty of Winter Planning Reserve Margins *
3	Reactive Capability of IBRs and Reactive Resource Adequacy *
4	Inverter Based Resource Modelling and Ride Through Capabilities *
5	Misoperations Due to Errors Occurring During Commissioning *
6	Vegetation Management of 100-200 kV Circuits *
7	Cold Weather Operation of SF6 Gas Insulated Circuit Breakers *
8	Overhead Transmission Line Ratings During Cold Weather *
9	Lack of Energy Assurance Assessments - **New**
10	Generation Availability During Severe Cold Weather - **New**

The four risks in the orange section of the O & P risk heat chart have been identified as having the highest relative risk and are:

- *BPS Modeling Accuracy*
- *Winter Reserve Margin Uncertainty*
- *Lack of Energy Assurance Assessments*
- *Generation Availability During Severe Cold Weather*

2022 MRO RRA Risks *Risk also identified in 2021 RRA

Top Operational and Planning Risks

- **BPS Modeling Accuracy**
  - Many model builders contribute to the development of a single EI model
  - The following pieces must fit together accurately to have a reliable set of BPS models:
    - Inverter-based generation (parameters, limitations)
    - The changing characteristics of load
    - Distributed energy resources netting with load
    - Market flow basecase assumptions
    - Interchange balancing between BAs
    - Short circuit modeling for protection equipment

Top Operational and Planning Risks

Uncertainty of Winter Planning Reserve Margins

- The 2020/2021 winter planning reserve margins (PRM) for ERCOT, SPP and MISO were forecasted to be 49%, 59%, and 50%, respectively

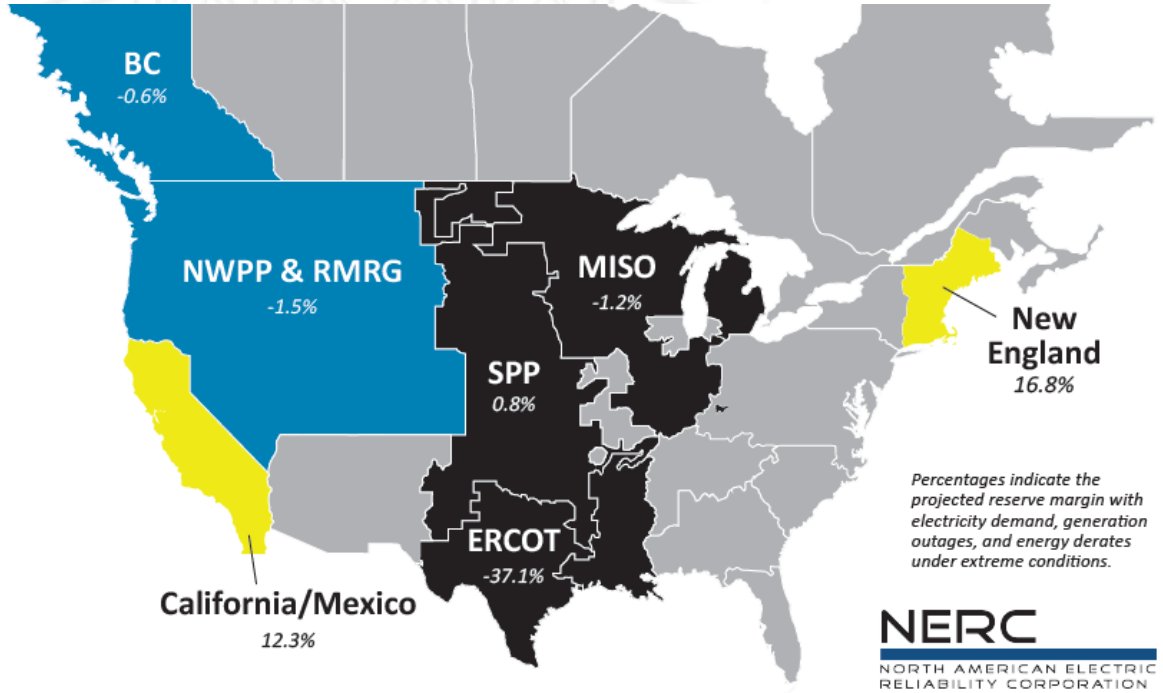
PRM = Margin between Anticipated Resources & Anticipated Load

- In February 2021,all three RTOs experienced unanticipated generation outages combined with unanticipated load spikes and low wind speeds.

- ***Result:*** Manual firm load shed totaling 23,400 MW
  - *the largest manual firm load in US history.*

Top Operational and Planning Risks

- Uncertainty of Winter Planning Reserve Margins



Top Operational and Planning Risks

- **Lack of Energy Adequacy Assessments**
  - NERC Energy Reliability Assessment Task Force (ERATF) was formed in February, 2021
  - ERATF will lay out the framework for performing energy assurance assessments
  - These assessments will compliment the traditional resource adequacy assessments (planning reserve margins)
  - Will help assure energy assurance throughout the year, 8,760 hrs.
  - Imperative due to the changing resource mix and uncertainty of fuel sources in the real-time.

Top Operational and Planning Risks

- **Generation Availability in the Southern Midwest During Sub-freezing Temperatures**
  - Natural gas generation often not winterized for sub-freezing temperatures
  - Forced outages occur last minute, resulting in large scale capacity and energy shortages
  - Natural gas generation also subject to fuel shortages and non-firm contracts
  - Natural gas facilities also subject to shutdown during sub-freezing temperatures: ***Electric/Gas Infrastructure Interdependencies***

2021 State of Reliability Report

Figure 5.1: 2010 and 2020 North America-Wide Capacity Resource Mix

Table 5.1: Generation Resource Capacity by Fuel Type				
Generation Fuel Type	2010 On-Peak		2020 On-Peak	
	GW	Percent	GW	Percent
Coal	294.9	27.7%	235.9	22.6%
Natural Gas	417.7	39.2%	447.2	42.9%
Hydro	165.6	15.5%	140.7	13.5%
Nuclear	114.0	10.7%	110.1	10.6%
Oil	27.8	2.6%	40.2	3.9%
Wind	17.0	1.6%	24.7	2.4%
Solar	0.0	0.0%	21.4	2.1%
Other	28.9	2.7%	22.2	2.1%
Total:	1,065.8	100.0%	1,042.5	100.0%

Changing Resource Mix:

Installed wind nameplate = 122 GW in 2020, yet accredited wind capacity at peak load is 24.7 GW (or 2.4% of total resource capacity).

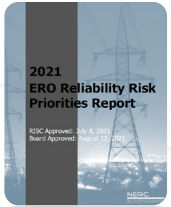
Total capacity has dropped by 23 GW from 2010 to 2020, however total load has increased by about 85 GW in the same 10 years.

2021 Long Term Reliability Assessment

Solar and Wind Nameplate Capacity, Existing and Planned Additions through 2031										
Assessment Area	Nameplate MW of Solar					Nameplate MW of Wind				
	Existing	Tier 1	Tier 2	Tier 3	Total	Existing	Tier 1	Tier 2	Tier 3	Total
MISO	728	10,989	53,756	4,907	**70,380**	22,854	5,593	14,649	730	**43,826**
MH	0	0	0	0	**0**	259	0	0	0	**259**
SPC	2	10	10	57	**79**	242	385	200	100	**927**
SPP	278	444	32,170	149	**33,041**	27,535	4,604	16,892	0	**49,031**
Total	1,008	11,443	85,936	5,113	**103,500**	50,890	10,582	31,741	830	**94,043**

Solar and Wind Nameplate Capacity, Existing and Planned Additions through 2031

ERO and MRO Reliability Risk Correlation

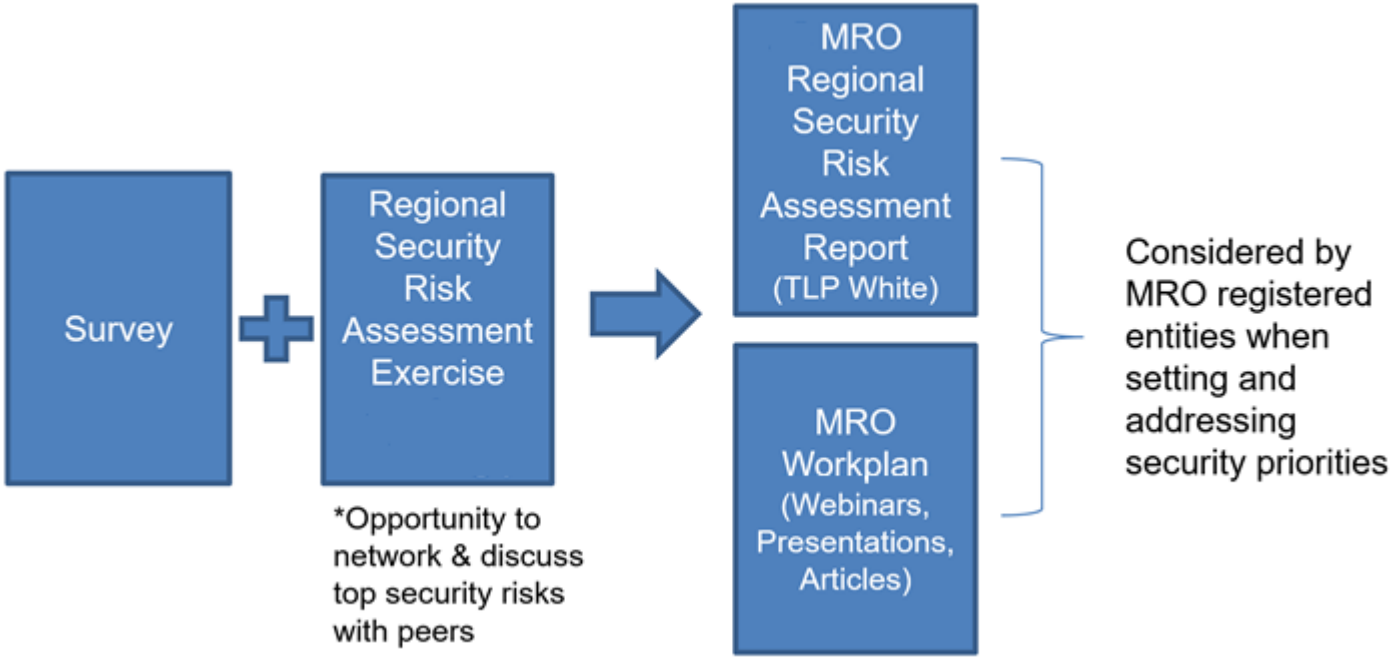


Changing Resource Mix	Resource Adequacy and Interdependencies	Extreme Natural Events	Bulk Power System Planning	Protection System Complexity and Human Performance
Bulk Power Modeling Accuracy	Generation Availability During Cold Weather	Uncertainty of Winter Reserve Margins	Bulk Power Modeling Accuracy	Misoperations Due to Commissioning Errors
Reactive Resource Adequacy	Reactive Resource Adequacy	Cold Weather Operation of SF6 Breakers	Reactive Resource Adequacy	
Lack of Energy Assurance Assessments	Lack of Energy Assurance Assessments	Generation Availability During Cold Weather	Lack of Energy Assurance Assessments	
	Inverter Based Resource Capabilities	Transmission Line Ratings During Cold Weather		

Steen Fjalstad, Director of Security

MRO 2022 Regional Security Risks

MRO SAC Regional Security Risk Assessment (RSRA) Process



MRO Security Risk Priorities for 2022

MRO Reliability Risk Matrix - Physical and Cyber Security Risk Rankings						
Consequence/Impact (C)		Likelihood (L)				
		L1	L2	L3	L4	L5
		Very Unlikely	Unlikely	Possible	Likely	Almost Certain
C5	Severe					
C4	Major				7	
C3	Moderate			4 5		
C2	Minor		1 6	2 3 8 9 11		
C1	Negligible			10		

	Physical and Cyber Security Risks
1	Inability to Access and/or Apply Threat Intelligence - **New**
2	Inadequate Resources *
3	Focus on CIP Compliance *
4	Insider Threat *
5	Malware/Ransomware - **New**
6	Security Awareness & Training - **New**
7	Supply Chain Compromise *
8	Vulnerability & Support Challenges of Legacy Devices *
9	Asset Inventory & Management - **New**
10	Network Visibility & Monitoring - **New**
11	Perimeter Security & Controls - **New**

2022 MRO RRA Risks *Risk also identified in 2021 RRA

The three risks in the orange section of the security risk heat chart have been identified as having the highest relative risk and are:

- *Supply Chain Compromise*
- *Insider Threat*
- *Malware/Ransomware*

Top Cyber and Physical Security Risks

- **Supply Chain Compromise**
  - Recent events
    - BPS and corporate
  - Impacts other risks
  - People
    - Access (OEM, vendors)
  - Process
    - Patch management, vendor assessment
  - Technology
    - Hardware, software, sub-components

Top Cyber and Physical Security Risks

- **Insider Threat**
  - BPS and corporate
    - Sensitive access with company specific insight
  - Remote access & work from home element
  - Behavioral indicators

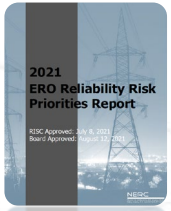
Top Cyber and Physical Security Risks

- **Malware/Ransomware**
  - Recent events
    - BPS and corporate
  - Pervasive to all systems
  - Exposes internal controls
    - Security awareness, IT/OT convergence, network segmentation, preparedness

Top Cyber and Physical Security Risks

- **Focus on CIP Compliance**
  - Rapid change in technologies
    - Rear view mirror vs windshield
  - Administrative burden of evidence gathering
  - Possible false sense of security

ERO and MRO Security Risk Correlation



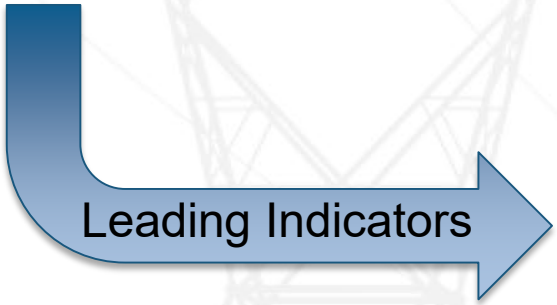
Cybersecurity Vulnerabilities	Loss of Situational Awareness	Physical Security Vulnerabilities	Human Performance and Skilled Workforce
Asset Inventory & Management	Network Visibility & Monitoring	Perimeter Security & Controls	Focus on CIP Compliance
Inadequate Resources	Perimeter Security & Controls	Insider Threat	Inadequate Resources
Insider Threat	Inability to Access and/or Apply Threat Intelligence	Security Awareness & Training	Security Awareness & Training
Malware/Ransomware		Inadequate Resources	Vulnerability & Support Challenges of Legacy Devices
Supply Chain Compromise			
Network Visibility and Monitoring			

Lee Felter, Principal Risk Assessment and Mitigation Engineer

MRO 2021 – 2022 CMEP Indicators

Identifying CMEP Highlights

- **Emergent Standards - observations**
  - HEROS
  - Individual outreach engagements
  - SDT involvement



Risk Reducing Controls

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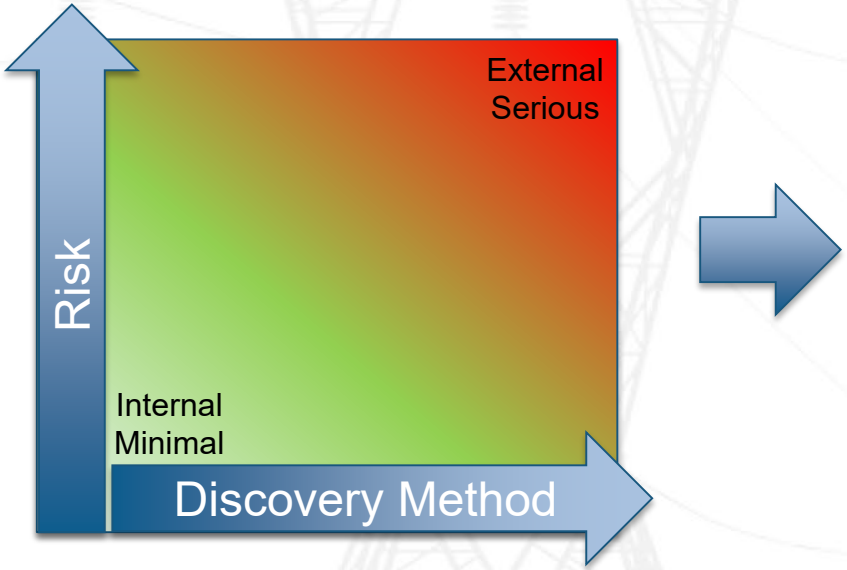
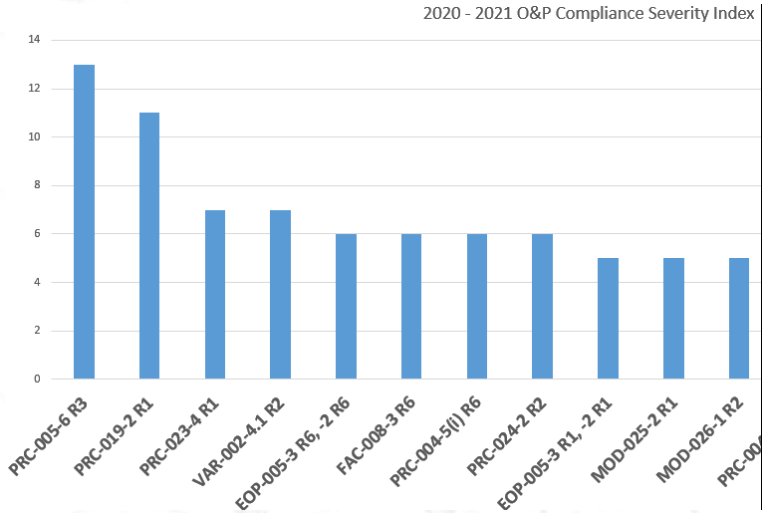
Identifying CMEP Highlights

- **CSI = Assessed Risk * Discovery Method → Recent Trend Research**





Identifying CMEP Highlights

- **Recent Trends**
  - 2021 – 2022 high Compliance Severity Index requirements
    - Common root causes
    - Other standout observations

Risk Reducing Controls

Lagging Indicators

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High CSI Trends