EEI
Edison Electric INSTITUTE

Serious Injury and Fatality (SIF) Precursor Customization Project

Research Summary

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Precursor Analysis Research Team

To be inclusive of the electric power generation and delivery sector, the research team included safety professionals from EEI member energy companies as well as from the public power, contractor and scientific communities.

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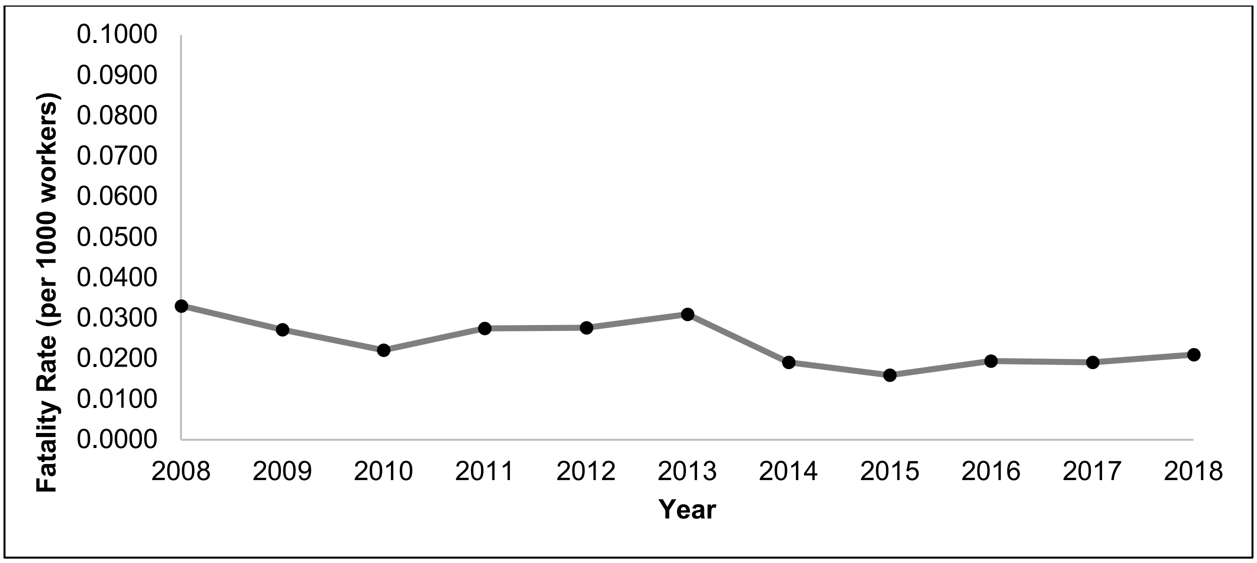
INTRODUCTION

Despite continuous improvement efforts, the fatality rate in the electric power generation and delivery sector has plateaued over the last decade (see Figure 1). To address this ongoing concern, researchers have begun to develop methods specifically targeted to prevent serious injuries and fatalities (SIF events). While not a guarantee of prevention, precursor analysis recently has emerged as a potentially viable method for preempting SIF events by making accurate assessments of the likelihood of a SIF event from brief conversations with field personnel prior to work.

Figure 1 – Fatality Trends in Electric Power Generation and Delivery (3-year moving average). From EEI Annual Safety Survey



Precursor analysis began with the National Aeronautics and Space Administration (NASA), which created the Accident Precursor Analysis (APA) program in response to a series of catastrophic events during shuttle launch. Following NASA, the Aviation Safety Action Program (ASAP) and the nuclear industry's Accident Sequence Precursor (ASP) program were developed. Most recently, the Construction Industry Institute adapted precursor analysis to the construction industry. Their study revealed the 16 most predictive precursors for general construction, shown in the list below.

General industry precursor list:

1. Unaware of the work procedure
2. Working alone
3. Poor pre-task plan
4. Poor plan to address work changes
5. Evidence of improvisation
6. Long working hours
7. Fatigue
8. Unusual schedule pressure
9. Poor contractor safety control
10. Poor hazard recognition
11. Lack of physical controls
12. Limited safety supervision
13. Inexperienced team leader
14. Poor engineering controls
15. Congested workspaces/crowding
16. Poor attitude toward safety

The Edison Electric Institute (EEI) organized a team of practitioners and a technical advisor to customize the method for electric power generation and delivery. This report documents the efforts of this team and conveys the rigor of the process. The team started with the precursors validated for general industry, brainstormed new precursors, collected empirical field data, and used advanced statistics to identify the precursors most relevant to electric power generation and delivery. The result was a validated methodology for engaging with field personnel prior to work and making assessments of SIF potential.

DEFINITIONS

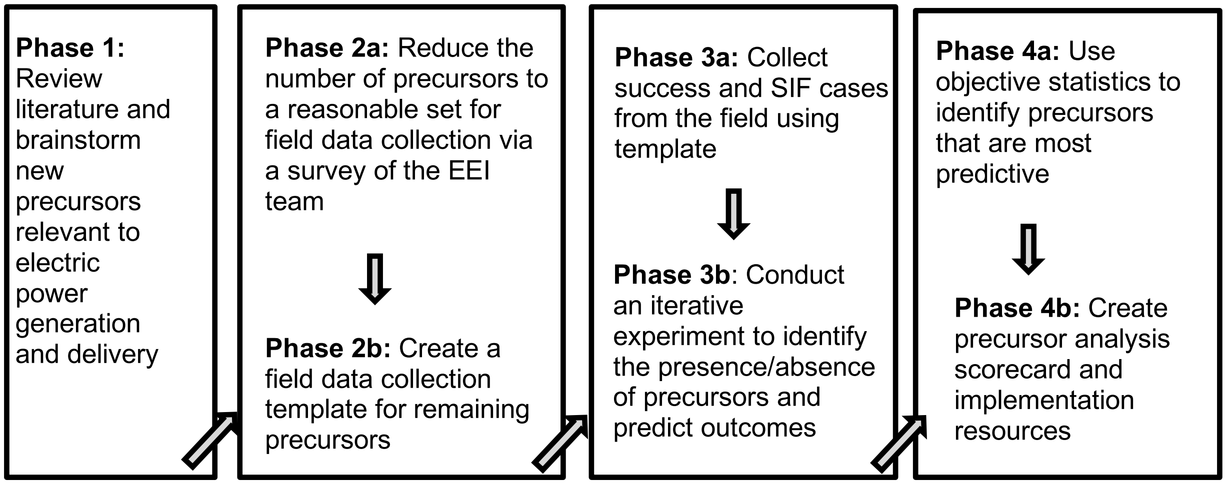
To ensure consistency in the process, the team adopted a set of important definitions. First, Precursor Analysis was defined as *the process of observing an environment and engaging with field personnel to determine if warning signs of SIF events are present.* In simple terms, precursor analysis helps to identify if known ingredients of a SIF event are present before work starts. Second, a SIF event was defined as *an event that resulted in or had the potential to result in a life-changing injury*. Under this definition, high-potential near misses and low-severity incidents that had the potential to be fatal also were included. This was important as it increased the number of learning opportunities that was leveraged by the team. Third, consistent with the Construction Industry Institute study, precursors were defined as *reasonably detectable events, conditions, or actions that serve as warning signs of a SIF event.* A key aspect of this definition is the focus on information that can be obtained from a brief conversation with workers and a cursory observation of the work. Finally, a Field Safety Engagement was defined as *the process of engaging with field personnel to collect information needed to perform a precursor assessment.* These engagements are typically comfortable conversations among an observer and worker(s).

RESEARCH OVERVIEW

The research process was extensive and scientifically rigorous. The four phases used to customize precursor analysis are illustrated in Figure 2. The methods and results of these phases are described in detail in this report.

An important attribute of this project was the qualification of the EEI team. The 12 active members of the team average 24 years of experience in the industry and 12.5 years of experience in safety management. All hold leadership roles in their organizations pertaining to the investigation of serious injuries and fatalities. Five members have field experience working as a line worker or working in a power generation facility with an average 20 years of experience among them. Finally, the technical advisor possesses a PhD with an emphasis on engineering and occupational safety and health and has 15 years of experience with safety-related research. These collective credentials meet typical academic standards to qualify as an expert group.

Figure 2 – Overarching Precursor Customization Process



Phase 1: Identifying a comprehensive set of potential precursors

Objective 1: Review literature and brainstorm new precursors relevant to the electrical power generation and delivery

The starting point for the development of a custom precursor assessment strategy was the set of 16 precursors validated for the general construction industry. Given the goal of customization for the electric power generation and delivery sector, the team attempted to identify as many new candidate precursors as possible. This was achieved through a literature review and traditional brainstorming approach to leverage the knowledge and experience of the team. At this stage, all potential precursors were considered.

To begin, all available literature pertaining to precursor analysis was reviewed, focusing primarily on the most successful precursor programs. For example, NASA, the nuclear industry, and the aviation industry all have publicly available handbooks providing lists of detailed precursors. Additionally, the Department of Energy published the *Human Performance Handbook*, which included a summary of known agents that cause human error in workplace settings (e.g., unfamiliarity with the task, imprecise communication, and personality conflicts). The review of validated literature yielded 31 new potential precursors.

To supplement the literature review, team members shared company resources related to root cause assessments, human factors engineering, and error avoidance. This information was used to brainstorm new precursors. The brainstorming process took place over a day-long meeting, where team members were asked to describe clearly the proposed new precursors and to provide examples when possible. This process yielded 12 new precursors.

In summary, the final list of 59 precursors included 16 validated for general construction, 31 new precursors found in literature, and 12 new precursors derived through team brainstorming. All 59 potential precursors are identified in Appendix 1. For reference, those with an asterisk (*) are the precursors validated for the general industry study. All others were considered in this study for the first time.

Phase 2: Reducing the number of precursors for investigation and creating a case collection template.

Objective 2a: Reduce the number of precursors to a reasonable set for field data collection

Objective 2b: Create a field data collection template

Once a comprehensive list of precursors was created and clearly defined, the next step was to prioritize a subset for further investigation. A subset of precursors was needed because it would be too cumbersome and disruptive to work to collect data on active sites for all 59 precursors. Thus, the team's goal was to narrow the comprehensive list to a subset of 20 to 30 precursors that have highest potential to be predictive and are applicable to both electric power generation and delivery.

Reducing the size of the precursor investigation set was achieved through an online and anonymized survey of the team. All team members were asked to rate the extent to which each of the 59 precursors was potentially predictive in nature. Ratings were provided on a Likert scale where 1 was low (not preferable) and 5 was high (preferable). Once the survey was completed, the 30 precursors with the highest scores were selected. Then, the other criteria – generalizability and assessability – were considered by the team and two precursors were dropped. First, imprecise communication was dropped because the team perceived that it applies mainly to power generation and has limited use for delivery. Second, substance abuse was dropped because the team did not believe this could be reasonably assessed accurately in the field through cursory observation and brief discussion with the workers. Also, this precursor is detected and managed through formal testing. The process yielded an investigation set of 28 potential precursors, which met the original goal of 20-30 for empirical data collection.

Once the set of precursors was identified for further investigation, the goal was to design questions that could be asked of workers to identify if each potential precursor was present or absent. For example, one potential precursor was *productivity pressure*. To collect information from workers in the field, the following questions were designed: *"What might cause the crew to feel pressured to work quickly today?"* and *"Once the job is complete, what's next?"* The questions needed to assess the 28 precursors comprised the interview script used in the 'case data collection template.' The template included a very long set of questions that took more than 1 hour to administer. The analysis presented in later phases allowed the team to optimize this time burden to approximately 20 minutes by narrowing the subset of precursors only to those that were most predictive. In future phases, the term *case* referred to a work situation – either SIF or non-occurrence of SIF – that included all the answers to the questions and observations needed in the case template.

Phase 3: Creating an objective dataset by conducting iterative experiments using field data

Objective 3a: Collect success and SIF cases from the field

Objective 3b: Conduct an iterative experiment to identify the presence/absence of precursors and predict outcomes

Once the precursor questionnaire was created, the next step was to collect as many cases from the field as possible for use in a subsequent experiment. The team's goal was to establish a sample of cases in which there was an approximately equal distribution of SIF events and non-occurrence of SIF events, and an equal distribution of cases from electric power generation and electric power delivery. For clarity, a SIF case was one in which a potentially serious near miss or a life-changing event occurred. Alternatively, a non-occurrence of SIF case was one in which potentially dangerous work was performed without incident. The table below shows the distribution of the 40 cases collected and analyzed.

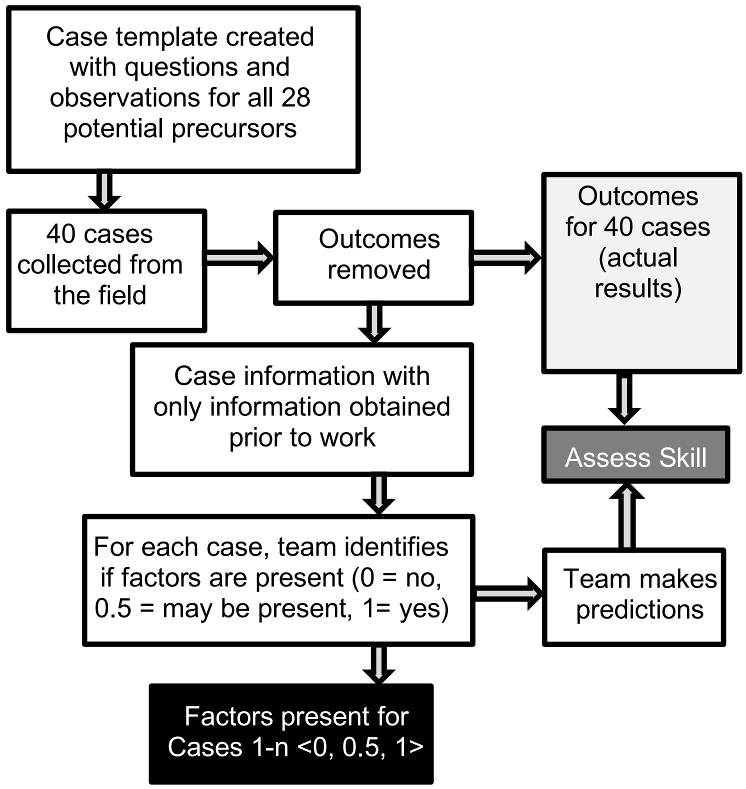
Table 1 – Distribution of the 40 cases by outcome type and work type

Work type	SIF	Non-Occurrence	Total
Generation	8	8	**16**
Delivery	12	12	**24**
Total	**20**	**20**	**40**

Data was collected by EEI team members using the 'case data collection template' for 40 work periods (cases). These cases each were reviewed by at least 10 EEI team members in face-to-face meetings, and an experiment was conducted. The experiment had two purposes: (1) to assess the presence or absence of all 28 precursors for all 40 cases and (2) to measure the extent to which the team members correctly could predict the outcome of a case using only information available prior to work. To ensure rigor in the process, a few experimental controls were implemented. First, the team members who collected the case were precluded from participating in the assessment for that case. Second, all cases were edited for tense and grammar by the technical advisor so that the outcome of the case could not be inferred from the structure of the language. The technical advisor only managed the process and made observations but did not make predictions to avoid undue biasing of other team members. Third, the order of the cases was randomized to avoid any unintended patterns. Finally, the outcomes of the cases were not revealed until the end of each meeting.

During the experiment, two members of the team read each case aloud, with one individual serving as the interviewer (observer) and the other serving as the interviewee (worker or group of workers). During the review of each case, the team members were asked to complete an online form individually in which they identified whether each of the 28 potential precursors was present (indicated by a score of 1), partially present (score of 0.5), or not present (score of 0). At the end of the form, each team member was asked to make a prediction of the outcome (SIF or non-SIF). This experimental process is illustrated in Figure 3 below.

Figure 3 – Experimental process, where boxes in white indicate team activities, black indicate resulting data, and gray indicate a measure of predictive performance.



The results of the experiment indicated a high level of predictive accuracy, with 70 percent of individual predictions being correct. Such skill is significantly better than random (p-value = $1.6 * 10^{-3}$), which is a typical indicator of strong predictive skill. Although the team's skill in making predictions was interesting, ultimately a statistical model for making objective and scientifically rigorous predictions was desired. To this end, the data from the experiment was organized into a matrix of 28 precursors by 40 cases. Because each individual rated the presence or absence for each precursor and each case, the total number of assessments per individual was 1,120 (28 precursors x 40 cases) and a total of 11,200 ratings for the entire team (1,120 ratings per member x 10 members). This matrix of data included the presence or absence of each precursor that could be related statistically to the known actual outcome of each case.

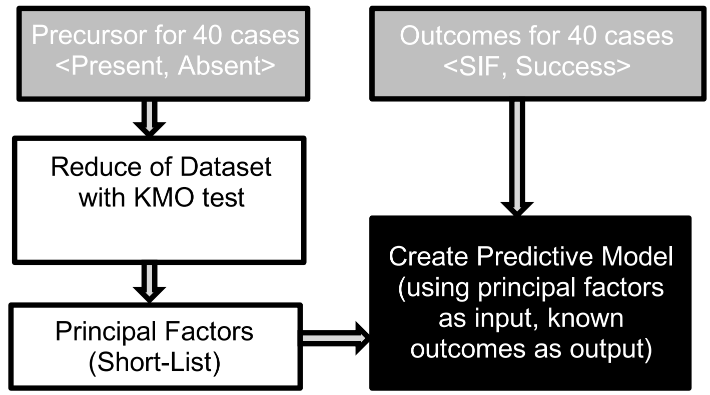
Phase 4: Creating a predictive model and precursor analysis scorecard

Objective 4a: Use objective statistics to identify precursors that are most predictive

Objective 4b: Create precursor analysis scorecard and implementation resources

The data from the iterative experiment resulted in a high-dimension dataset suitable for statistical analysis. The purpose of the statistics was two-fold. First, data reduction techniques were used to identify the subset of precursors that were most suitable for analysis. Second, logistical regression was used to create a predictive model that indicates the relative importance (i.e., predictive capacity) of each precursor in terms of making a prediction of the actual outcome. This final model was used to create the structure, weights, and interpretation of the precursor analysis scorecard. The statistical process is summarized in Figure 4.

Figure 4: Statistical Modeling Techniques to Create a Predictive Model



The statistical modeling took the form of a two-step process. First, the number of potential precursors was reduced using the Kaiser-Meyer-Olkin (KMO) test. The KMO test measures the suitability of each precursor for factor analysis as indicated by the sampling adequacy. A KMO score of less than 0.5 justified the removal of a precursor. Practically, this test measures whether each precursor has a suitable distribution across SIF and non-occurrence of SIF cases to differentiate the outcomes in the final model. For example, if a precursor is present in both SIF and non-occurrence cases, it would not be helpful in distinguishing between the outcomes. Alternatively, a precursor that is present only in SIF cases would be an excellent differentiator of success and failure. The KMO test helped reduce the dataset to 13 precursors that were used to create a predictive model.

The 13 remaining precursors are shown in Table 2. As one can see, every retained precursor was present significantly more often in SIF than in non-occurrence cases. Thus, these precursors are present more often in SIF cases and less often in non-occurrence cases, indicating their capacity to differentiate non-SIF from SIF.

Table 2: Final 13 precursors with descriptive statistics and weights.

Precursors	Present in SIF Cases	Present in Non-Occurrence Cases	Difference (SIF/non-SIF)	Scorecard Weight
Rules and Procedures	27%	2%	24%	3
Departure from Routine	24%	5%	20%	3
Hazard Recognition	22%	5%	17%	2
Safety Attitudes	22%	5%	17%	1
Workers Inactive in Safety	17%	2%	15%	2
Risk Normalization	32%	20%	12%	3
Safe Work Procedure	12%	2%	10%	3
Familiar with the Task	17%	7%	10%	2
Stop Work Execution	12%	2%	10%	2
Perceived Safety Culture	15%	7%	7%	3
Pre-Task Plan	20%	12%	7%	3

Plan to Address Change	22%	17%	5%	1
Productivity Pressure	20%	15%	5%	3

The remaining 13 precursors were used to create a predictive model. The presence or absence of each precursor comprised the set of independent variables (i.e., predictors) and the actual outcome of the case was the dependent variable (predictand). The dependent variables took the form of a binary dataset where 0 was used to represent non-occurrence and 1 to represent SIF. The independent variables took the form of a fuzzy input set where 0 represents the precursor as absent, 0.5 as partially present, and 1 as completely present. To check the adequacy of a simpler model, the independent variables also were tested as a dichotomous set where 0 represented absent and 1 represented partially present or completely present. Since the predictive capacity of both models was indistinguishable, the simpler model with binary independent variables was used. Logistical regression analysis was used to create a predictive equation that relates the precursor to the actual outcomes. This method is used in lieu of a traditional regression when the variables are not normally distributed.

The predictive model takes the form shown below:

$P_i = B_o + B_1X_1 + B_2X_2 + \ldots B_{13}X_{13}$

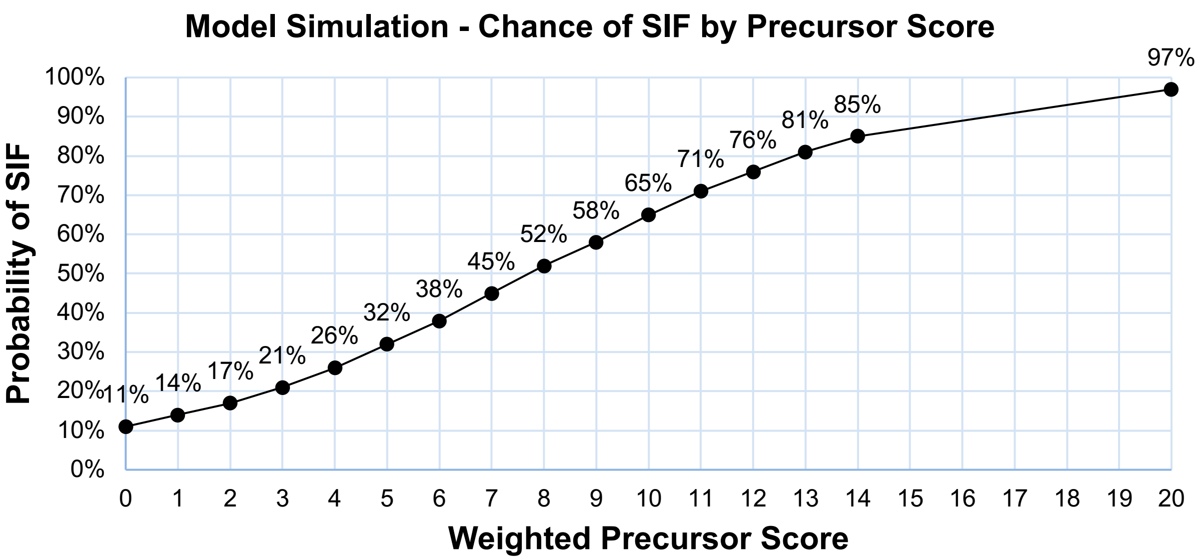
Where,
P_i is the probability of SIF for the case
B_o is the probability of a SIF when no precursors are present (intercept)
B_1 is the importance of the first precursor in contributing to the probability (weight)
X_1 indicates the independent variable where 0=absent, 1=present
Note that X_1 is precursor 1, X_2 is precursor 2, and so forth
Note that B_1 reflects the importance of precursor 1, B_2 reflects the importance of precursor 2, and so forth.

This modeling process considered the precursors as independent. However, the team hypothesized that there may be some interaction among precursors. For example, safety culture was hypothesized to impact attitudes. To investigate these potential interactions, a correlation matrix was created (see Table 3). This matrix shows the interaction between all 13 precursors, and statistically significant values are in bold. In practical terms, these interactions mean that some precursors like safety culture inflate the importance of other precursors.

Once such interactions were included in the model, the overall impact of each precursor was assessed and represented by the weights shown in Table 2. One can see that these values directly relate to the descriptive statistics shown (i.e., those with the highest importance in making the prediction also were those that were present in far more SIF than non-SIF occurrence cases). Practically, the weights for each precursor indicate the relative importance, where precursor with a weight of 3 is approximately three times more important in making a prediction than a precursor with a weight of 1. These weights were used in the final scorecard.

To interpret a precursor score for a case, a simulation was performed. In this simulation, all the weights for the precursors that were present in a case were summed to represent a score for each case. For example, if rules and procedures (weight = 3), safe work procedure (weight = 2), pre-task plan (weight = 2), and productivity pressure (weight = 1) were present and all others were absent, the total score for that case would be 8 (3+2+2+1=8). All 40 cases were used to create a simulation that showed the model predictions for the spectrum of possible weighted case scores. The results are shown in Figure 5.

Figure 5: Results of mathematical simulation to show likelihood of SIF based upon weighted precursor score from the scorecard.

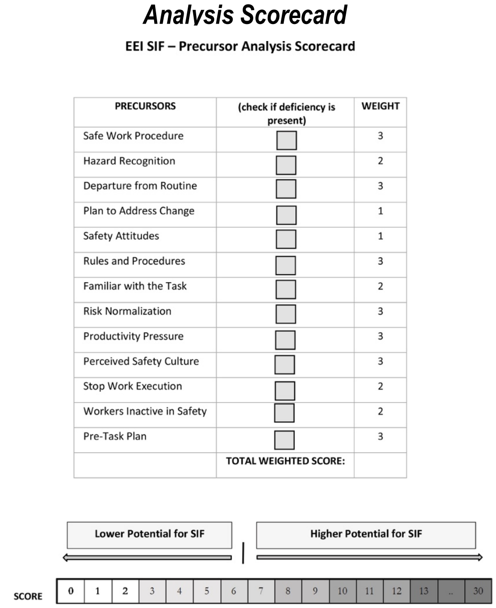


Creation of the Customized Scorecard

The team agreed that a complex equation is not suitable for field use. Thus, the precursor scorecard in Figure 6 was created to dramatically improve practicality without dramatically reducing precision. The weights in the scorecard were derived from the regression model, and the interpretation of the final score of a case (bottom of the scorecard) was based upon the simulation.

In this scorecard, a user simply needs to indicate whether each precursor is present or absent in a new case. Then, the weights for all selected precursors are summed. The interpretation scale at the bottom of the scorecard corresponds to the results of the simulation from Figure 5. The team was

Figure 6: Customized Precursor Analysis Scorecard



EEI SIF – Precursor Analysis Scorecard

PRECURSORS	(check if deficiency is present)	WEIGHT
Safe Work Procedure	☐	3
Hazard Recognition	☐	2
Departure from Routine	☐	3
Plan to Address Change	☐	1
Safety Attitudes	☐	1
Rules and Procedures	☐	3
Familiar with the Task	☐	2
Risk Normalization	☐	3
Productivity Pressure	☐	3
Perceived Safety Culture	☐	3
Stop Work Execution	☐	2
Workers Inactive in Safety	☐	2
Pre-Task Plan	☐	3
	TOTAL WEIGHTED SCORE:	

Lower Potential for SIF | Higher Potential for SIF

SCORE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	..	30

careful not to be prescriptive about actions that should be taken based upon a precursor score because the results are indicative of likelihood. Organizations must devise their own interpretation of likelihood and design appropriate actions given their interpretation.

Table 3: Correlation Matrix

	Safe Work Procedure	Hazard Recognition	Departure from Routine	Plans to Address Change	Safety Attitudes	Rules and Procedure	Familiar with Task	Risk Normalization	Productivity Pressure	Perceived Safety Culture	Stop Work Execution	Workers Inactive in Safety	Pre-Task Plan
Safe Work Procedure	1												
Hazard Recognition	0.37	1											
Departure from Routine	-0.12	-0.16	1										
Plans to Address Change	0.23	0.30	0.02	1									
Safety Attitudes	**0.53**	**0.62**	-0.04	0.30	1								
Rules and Procedure	0.18	0.21	0.17	0.24	0.33	1							
Familiar with Task	0.08	**0.42**	0.13	0.24	0.16	0.25	1						
Risk Normalization	0.26	0.25	0.08	0.37	0.36	0.19	0.09	1					
Productivity Pressure	-0.01	-0.10	**0.55**	-0.06	0.13	0.21	-0.06	0.17	1				
Perceived Safety Culture	**0.44**	**0.47**	0.04	**0.42**	**0.61**	0.30	0.10	0.39	0.23	1			
Stop Work Execution	0.02	0.37	0.18	0.09	0.37	0.18	0.08	0.40	0.13	**0.44**	1		
Workers Inactive in Safety	**0.67**	0.53	-0.05	0.36	**0.53**	0.49	0.29	0.23	0.03	**0.63**	0.32	1	
Pre-Task Plan	0.16	0.29	-0.10	0.20	0.29	-0.10	-0.03	0.02	-0.17	0.27	0.16	0.19	1

CONCLUSIONS AND RECOMMENDATIONS

The EEI team followed a challenging and scientifically rigorous process to arrive at a customized precursor analysis methodology for electric power generation and delivery. This process combined the expert judgment of 10 dedicated industry professionals, a controlled experiment using empirical field data, and cutting-edge statistical modeling performed by a qualified technical advisor. The rigorous process was used to arrive at a precise equation; however, to ensure practicality, the equation was converted into a scorecard using a simulation. The team invested this time and effort to inspire confidence in the final product. The purpose of this report was to summarize the details of this process.

The team recognizes that there are limitations to the process that should be considered. First, it is possible that some relevant precursors were not identified through literature and brainstorming and would not be included. Second, the subjectivity associated with identifying whether a precursor is present or absent cannot be removed from the process. Thus, organizations need robust calibration efforts to ensure consistency in the application of the method. Finally, the detailed nature of the field data collection made it impossible to collect a very large sample size. This resulted in a relatively small sample of 40 cases. As organizations begin to pilot test the method, data should be pooled so that the method can be validated and the equations can be tuned with a larger sample.

The team also recognizes that the customization process is not complete. Working groups are recommended to establish best practices, conduct validation and calibration efforts, and to further consider limitations of the method. The present work product is an important step toward SIF prevention but its use is not a guarantee that SIF events will not occur. If implemented, the method should be integrated into an overall safety management system with a foundation of established safety practices.

For more information on the team’s recommendations for implementation, readers are referred to the *Implementation Guide*.

Appendix 1 – Precursors

**Denotes a precursor validated for general industry*

#	Precursor	Description	Those scoring high in team survey	Those with sufficient KMO scores
1	Safe Work Procedure*	Workers cannot express the core elements of the safe/standard workplan for their task.	X	X
2	Hazard Recognition*	Workers do not recognize hazards or properly evaluate the severity of risks.	X	X
3	Departure from Routine	Unfamiliar or unforeseen task or job site conditions that depart from a well-established routine.	X	X
4	Plan to Address Work Change*	Workers do not stop and reassess conditions when work changes from what is planned (i.e., switch to plan B).	X	X
5	Safety Attitudes	Workers demonstrate priority of productivity, heroic tendencies, invulnerability, fatalism, or summit fever.	X	X
6	Rules and Procedures	Adequate rules and procedures are documented and communicated but not followed by workers. The correct procedure is documented and communicated to workers but they are not followed.	X	X
7	Familiarity with Task	Workers are not familiar with task expectations or performance standards because of a lack of experience or significant procedural change.	X	X
8	Risk Normalization	Lower perception of risk or higher risk tolerance resulting from repeated exposures. Tied to procedural drift.	X	X
9	Productivity Pressure*	Workers feel an unusual amount of pressure to work quickly and complete their task.	X	X
10	Perceived Safety Culture	Lessons learned from previous projects and events are not incorporated into planning and execution.	X	X
11	Stop-Work Execution	Workers do not have the ability, or management does not encourage, stopping work to address hazards.	X	X
12	Workers Inactive in Safety*	Workers are not engaged with or diligently participating in safety activities.	X	X
13	Pre-Task Plan*	Workers have not completed an adequate pre-task safety plan.	X	X
14	Working Alone*	One or more workers are working out of eyesight or earshot of co-workers, especially when they are inexperienced.	X	

15	Control* Barriers	No control barriers are in place to prevent field personnel from interacting with hazards.	X	
16	Assumptions	Workers suppose or do not verify facts, provoked by an inaccurate mental model of the task.	X	
17	Multitasking	Workers perform two or more simultaneous activities.	X	
18	Improvisation*	Workers have the tendency to deviate from the plan with tool selection or procedures, especially when the plan changes.	X	
19	Significant Overtime*	Workers are working long hours for the day or week, especially if not at their discretion.	X	
20	Fatigue*	Workers are unusually fatigued, caused by a work-related or personal factor.	X	
21	Distractions*	Workers are distracted from their task by a distinct personal or work-related factor.	X	
22	Safety Devices	Workers could bypass critical devices to force operation of equipment in unsafe conditions.	X	
23	Use of PPE	Correct tools and PPE are provided by company but not properly used by workers.	X	
24	Equipment Identification and Steps	Equipment and devices are not properly identified and the safe steps for operation are not clearly communicated or documented.	X	
25	Communication Quality	Communication habits may cause misinformation, misinterpretation, or lack of communication.	X	
26	Prior Safety Performance is Poor*	Prior project safety performance is poor.	X	
27	Safety Supervision*	Workers have limited support from the safety function in terms of information, guidance, site visits, and engagements.	X	
28	Congestion*	Workers are exposed to an unusual amount of congestion or crowding in their work space.	X	
29	No Worker Involvement in Planning	Field workers have not reviewed and provided input for the design or planning of the work activity		
30	Lack of Discipline	Workers demonstrate a lack of operational discipline (i.e., doing the work the right way, even when no one is watching).		
31	Substance Use or Abuse	Workers are under the influence of drugs, alcohol, or Rx.		

32	Line of Fire is Uncontrolled*	A significant energy source is present and is not controlled.
33	Customer/Public Pressure	Customer pressure exerted through aggression, violence, or others imposed by the customer or public.
34	First Day Back After Time-Off	First day back after leave/vacation/other work disruption.
35	Extreme Temperatures	Unusually hot or cold working environment with sustained exposure.
36	Risk Substitution through Employee Selection	Management replaces workers who express discomfort with the safety/risk of the task.
37	Poor Quality or Inexperienced Field Management*	Field managers are not experienced, short-fused, inhibit communication, or are otherwise inadequate communication.
38	Personality Conflict	Incompatibility between two or more individuals working together on a task.
39	Crew Disruption	Crews are changing or are volatile on the project (i.e., same crew does not start and finish the job).
40	No Formal Procedure	The work was not formally planned and in writing.
41	New Crew	The crew has recently been formed and the members have not worked together very long, creating unfamiliarity between the crew members.
42	Unclear Plan	Unclear work objectives, expectations, roles, responsibilities, or work standards.
43	Complacency	Workers no longer demonstrate vulnerability and exhibit overconfidence with a dangerous task, especially at 7 to 9 years of experience.
44	Limited Memory	Forgetfulness demonstrated by an inability to attend to more than 2 channels of information at once.
45	Closed-Mindedness	Workers feel that ‘they have always done the work this way,’ even though an outsider would see it differently.
46	Cognitive Demand	Mental demands scanning, interpreting, deciding etc. are excessive and require unusual amounts of information.

47	Monotony	Workers perceive their work to be boring, repetitive, or unusually simple.
48	Irrecoverable Acts	A worker could take an action that, once taken, cannot be easily reversed.
49	Interpretation Requirements	Situations requiring “in-field” diagnosis, potentially leading to misunderstanding or application of incorrect procedure.
50	Confusing Displays or Controls	Installed displays and controls are confusing or exceed cognitive capabilities like memory and timing.
51	Problematic Instrumentation	Uncorrected equipment deficiency or programmatic defect that requires an unusual action that burdens the worker.
52	Hidden System Response	System does not respond to a worker when actions are taken or commands are given.
53	Unexpected Equipment Condition	System or equipment status creates an unfamiliar situation for the workers.
54	Lack of Alternative Indication	Inability to compare or confirm information about system or equipment state because of the absence of instrumentation.
55	Inadequate Contractor Pre-Qualification	Safety is not considered significant criteria in contractor selection.
56	Poor Engagement	There is poor engagement between host/client leadership and contractor leadership.
57	On-The-Job Training	Workers receive their training while working
58	Insufficient Refresher Training	Refresher training was inadequate or infrequent.
59	Risk Secrecy	Workers express hesitance to share incident information because of perceived retaliation, negative attention, incentive structure, or finger-pointing.

The **Edison Electric Institute** (EEI) is the association that represents all U.S. investor-owned electric companies. Our members provide electricity for about 220 million Americans, and operate in all 50 states and the District of Columbia. As a whole, the electric power industry supports more than 7 million jobs in communities across the United States. In addition to our U.S. members, EEI has more than 65 international electric companies with operations in more than 90 countries, as International Members, and hundreds of industry suppliers and related organizations as Associate Members.

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