

Accident Sequence Precursor (ASP) Program

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ASP Program History

- The NRC established the ASP Program in 1979 in response to recommendations made in [NUREG/CR-0400](#), “Risk Assessment Review Group Report.”
- Interest in the analysis of precursors due to the reactor accident of Three Mile Island (TMI) in March 1979.
- ASP analyses of events prior to the TMI accident revealed that a similar event occurred two years earlier at Davis-Besse.
- Risk-based operating experience of an established ASP Program may have helped to prevent the accident.

What Is an ASP Analysis?

- An accident sequence precursor is an observed event and/or condition(s) at a plant which, when combined with one or more postulated events (e.g., equipment failures, human errors), could result in core damage.
- Precursor threshold is conditional core damage probability (CCDP) or increase in core damage probability (ΔCCDP) $\geq 10^{-6}$.
 - For initiating event analyses, the threshold is the plant specific CCDP for a reactor trip with a loss of main feedwater and condenser heat sink.
- The threshold for a *significant* precursor is $\text{CCDP}/\Delta\text{CCDP} \geq 10^{-3}$.
- ASP analyses account for all applicable event information regardless of licensee performance.
 - Examples include: concurrently failed equipment, initiating events, and components out of service for maintenance.
 - Concurrent events and/or conditions are set to “TRUE” (to reflect the occurrence of the event or the unavailability of systems or components) in the plant-specific standardized plant analysis risk (SPAR) models to generate the CCDP/ ΔCCDP and identify dominant sequences and cut sets.

Program Objectives

- Provides an independent review of operating experience as directed by the Commission in SECY-98-228, Proposed Streamlining and Consolidation of AEOD Functions and Responsibilities.
- Fulfills NRC Safety Objective #1 (see [NRC Strategic Plan](#)) to evaluate domestic and international operating events and trends for risk significance and generic applicability.
 - The ASP Program was cited in Appendix B as one of three programs used to assess the efficacy of existing programs and to help shape the agency’s objectives and strategies for reactors. One of these programs (Industry Trends) was recently ended.
 - The ASP Program is the only risk-based NRC program that tracks industry-wide occurrence of risk significant events.
- Management Directive (MD) 8.7 regarding the NRC’s Reactor Operating Experience Program directs the Office of Nuclear Regulatory Research to review and evaluate operating experience for identification of precursors to potential core damage sequences.

Program Objectives (cont.)

- Significant precursors are an input into the annual Abnormal Occurrence (AO), NRC Budget Justification, and Performance and Accountability reports to Congress.
 - Assists in fulfillment of Agency Performance Goal #4 to prevent accident precursors and reductions of safety margins at commercial nuclear power plants (operating or under construction) that are of high safety significance.
- Provides feedback to improve the NRC SPAR models.
 - Examples include: common-cause interactions and events; operator recovery actions; inclusion of support systems; alternate success paths.
 - Models are used in a different manner (e.g., initiating event assessments) and reviews of model results allow for model improvements that aid other NRC programs [e.g., Significance Determination Process (SDP)].
 - Assists in fulfillment of the MD 8.7 requirement to provide feedback to agency risk models based on operating experience lessons learned from the application of these tools and models.

Program Objectives (cont.)

- ASP analyses are sent to licensees for incorporation into their operating experience programs.
 - Discussion and reviews with licensees increase knowledge on key modeling issues and assumptions.
 - Communication of risk-significant insights not associated with licensee performance can result in considerations of plant improvements.
- Provides insights into the Reactor Oversight Process (ROP) through the review and adoption of SDP results for ASP Program use.
 - All licensee event reports (LERs) are reviewed under the ASP Program.
 - Greater than GREEN findings are reviewed by ASP risk analysts for acceptance under ASP Program criteria with independent ASP analyses conducted for initiating events and for multiple, concurrent performance deficiencies (PDs) and equipment outages (windowed events).

Program Resources

- Program resources have significantly decreased over the past 10 years.
 - Some of these efficiencies were gained from ASP program changes documented in [Regulatory Issue Summary \(RIS\) 2006-24](#).
 - The ASP Program now accepts SDP risk evaluations in which no initiating event occurred and/or no concurrent failures/unavailabilities were present.
 - In addition, formal licensee reviews were limited to those with a preliminary CCDP/ Δ CCDP $\geq 10^{-4}$.
- ASP analyses are completed with in-house resources.

What Events Are Analyzed?

- INL reviews all LERs to determine if the events are potential precursors.
 - Events are screened out using conservative criteria:
 - Component failure with no loss of redundancy.
 - Short-term loss of redundancy in only one system.
 - Event that occurred prior to initial criticality.
 - Design or qualification error that was small relative to what was predicted.
 - Event bounded by an uncomplicated reactor trip.
 - Event with no appreciable impact on safety systems.
 - Event involving only post-core-damage impacts.
- The ASP Program also analyzes events that trigger increased inspection as part of the ROP.
 - Special inspection, augmented inspection, etc.
- If events occur that are typically known to be precursors (e.g., loss of offsite power events), the event analysis begins promptly.

Use of ROP Analyses

- If the event does not involve a reactor trip and there is a licensee PD identified, the SDP evaluation results are used as the ASP Program result.
 - Prior to [RIS 2006-24](#), the ASP Program performed independent analyses for all initiating events and degraded conditions.
 - Risk evaluations performed as part of the SDP are limited to analyzing individual licensee PDs; therefore, an independent ASP analysis is performed when multiple pieces of mitigating equipment are concurrently unavailable due to different causes.
- The ASP Program can use MD 8.3 analysis results; however, this is rarely done given the differences in program objectives.
 - MD 8.3 analyses are designed to provide a quick snapshot based on available information to determine if additional inspection resources should be allocated. Therefore, these analyses are often performed without the benefit of information discovered leading up to and during the inspection.

NRC Program Comparison

- Program Similarities

- The risk models and technical methods used in ASP analyses, SDP risk evaluations, and MD 8.3 assessments are the same.
 - SPAR models and SAPHIRE are used in all three processes.
- The same analysis guidance is used (RASP Manual).
 - Most of the methods used within the SDP and MD 8.3 (and contained in the RASP Manual) were derived from the ASP Program.

- Program Differences

- SDP evaluations are used to determine the safety significance of individual PDs identified during an inspection.
 - Each finding is analyzed individually.
 - Risk significant events with no licensee PD are screened out of the SDP.
- In contrast, the ASP program evaluates all potentially significant plant events and degraded conditions, and analyzes concurrent multiple degraded conditions together.
- ASP analyses are documented to facilitate more detailed review and for sharing with both internal and external stakeholders.

Analysis Comparison #1

- Transformer and breaker failures cause a loss of offsite power (LOOP) and de-energized safety buses at Byron Station, Unit 2.
 - **ASP:** Non-recoverable LOOP was modeled. In addition, if operators fail to isolate fault (by open transformer feeder breakers), then the emergency diesel generators (EDGs) would not be able to load to safety buses (causing an station blackout-like condition). Final CCDP was calculated to be 1×10^{-4} (strongly dependent on credit for operator action to isolate the fault).
 - **SDP:** Preliminary WHITE (i.e., low to moderate safety significance) finding initially. It was determined later that no PD existed, and therefore, no inspection finding was identified.
 - **MD 8.3:** Non-recoverable LOOP was modeled. However, the failure of EDGs to load was not modeled. Special inspection was recommended and performed based on CCDP of 7×10^{-6} (with consideration of other deterministic factors).
- While an inspection was conducted, the overall risk significance of the event was not fully documented until the ASP Program analysis was completed.
- ASP analysis results were used as part of the basis and review for a 10 *CFR* 2.206 petition involving lack of loss of phase protection at Byron.

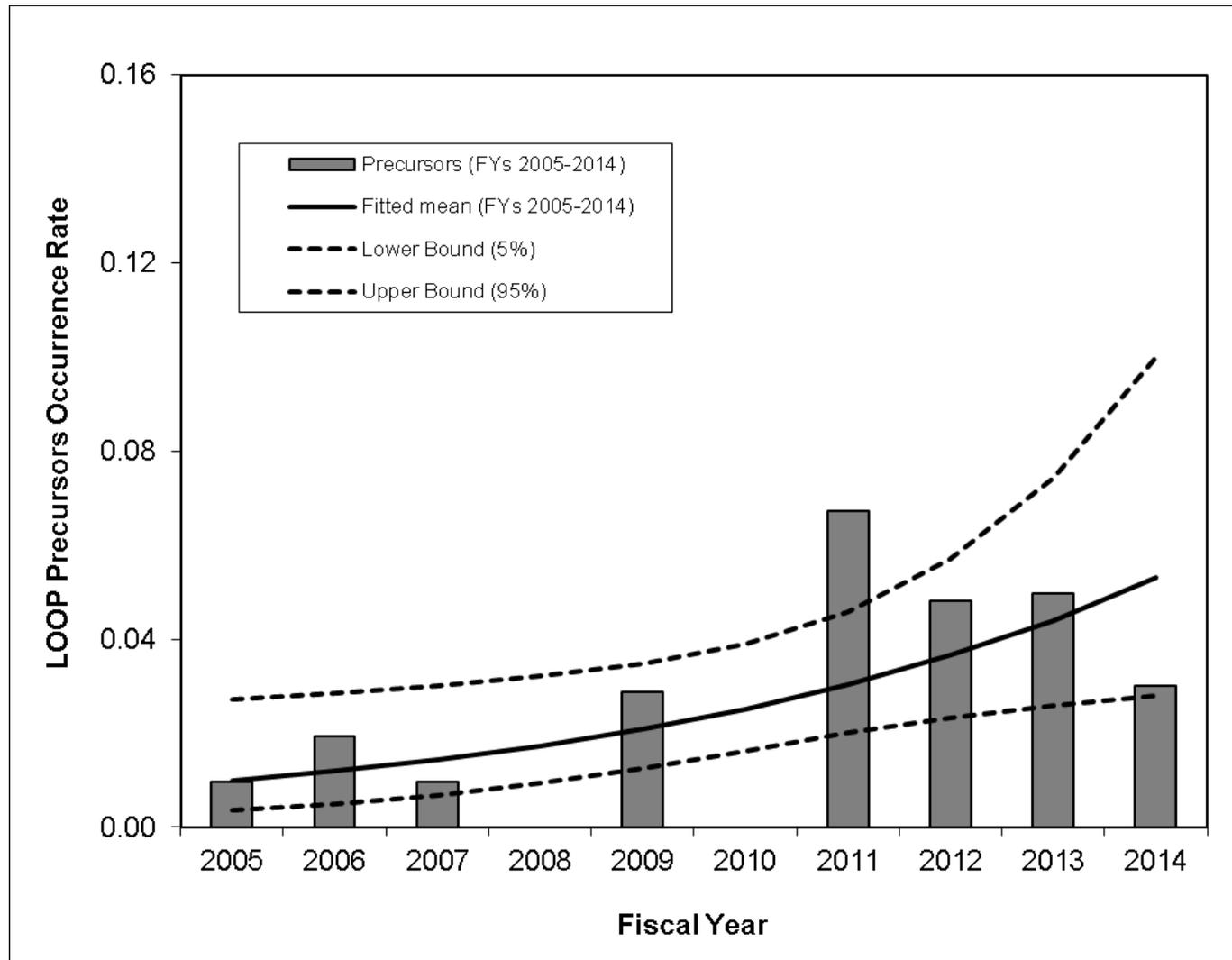
Analysis Comparison #2

- Electrical fault causes fire and subsequent reactor trip with a loss of reactor coolant pump (RCP) seal injection and cooling at H.B. Robinson.
 - **ASP:** Non-recoverable loss of main feedwater was modeled. In addition, RCP seal injection was being diverted away from RCP seals (unknown to operators) and component cooling water was isolated via return isolation valve (recovered by operators). Final CCDF was calculated to be 1×10^{-4} (strongly dependent on the evaluation of operator actions).
 - **SDP:** Two WHITE findings ($10^{-6} \leq \Delta CDF < 10^{-5}$) based on condition assessments of two individual PDs involving training and procedures. In addition, five GREEN findings (i.e., very low safety significance) were identified.
 - **MD 8.3:** Initial assessment did not include the RCP seal injection/cooling loss; therefore, a special inspection was originally recommended. A revised assessment was performed after the special inspection began, which led to an increase in the calculated safety significance CCDF of 4×10^{-5} and an augmented inspection was performed in response to this event.
- While an appropriate inspection (associated with the inspection findings) was performed, the complete risk significance of the event was not fully realized until the ASP analysis was performed.

ASP Results and Insights

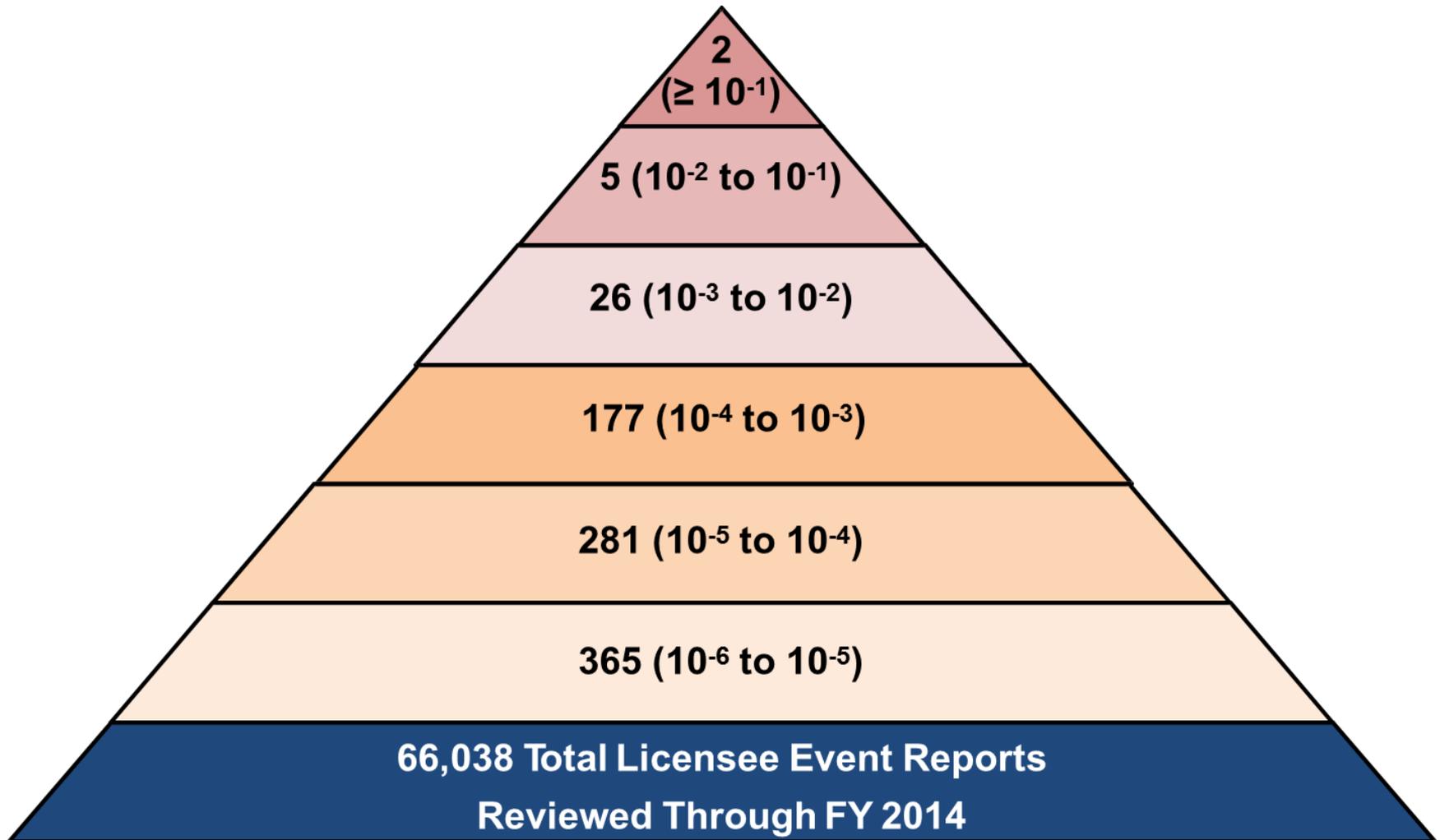
- The ASP Program is the only agency source of long-term trending of industry-wide operating experience of all risk-significant events that occur at U.S. commercial nuclear power plants.
- Recent trending identified a statistically significant increasing trend for precursors resulting from LOOP initiating events (2005 to 2014 data).
 - Of all precursors involving an initiating event, 50% are the result of a LOOP.
 - Of these precursors, 43% were caused by external events (e.g., tornadoes, hurricanes, lightning).
- In addition, recent increasing trends have been identified for precursors with a $CCDP/\Delta CDP \geq 10^{-4}$.
 - Seven of these events occurred in fiscal years 2010-2012.
 - In addition, there is currently a increasing trend for precursors with a $CCDP/\Delta CDP \geq 10^{-5}$ (formerly reported by the Industry Trends Program).
- These increasing trends resulted in initiation of a study of electrical distribution systems and key component failures important to risk.

LOOP Trend (FYs 2005–2014)

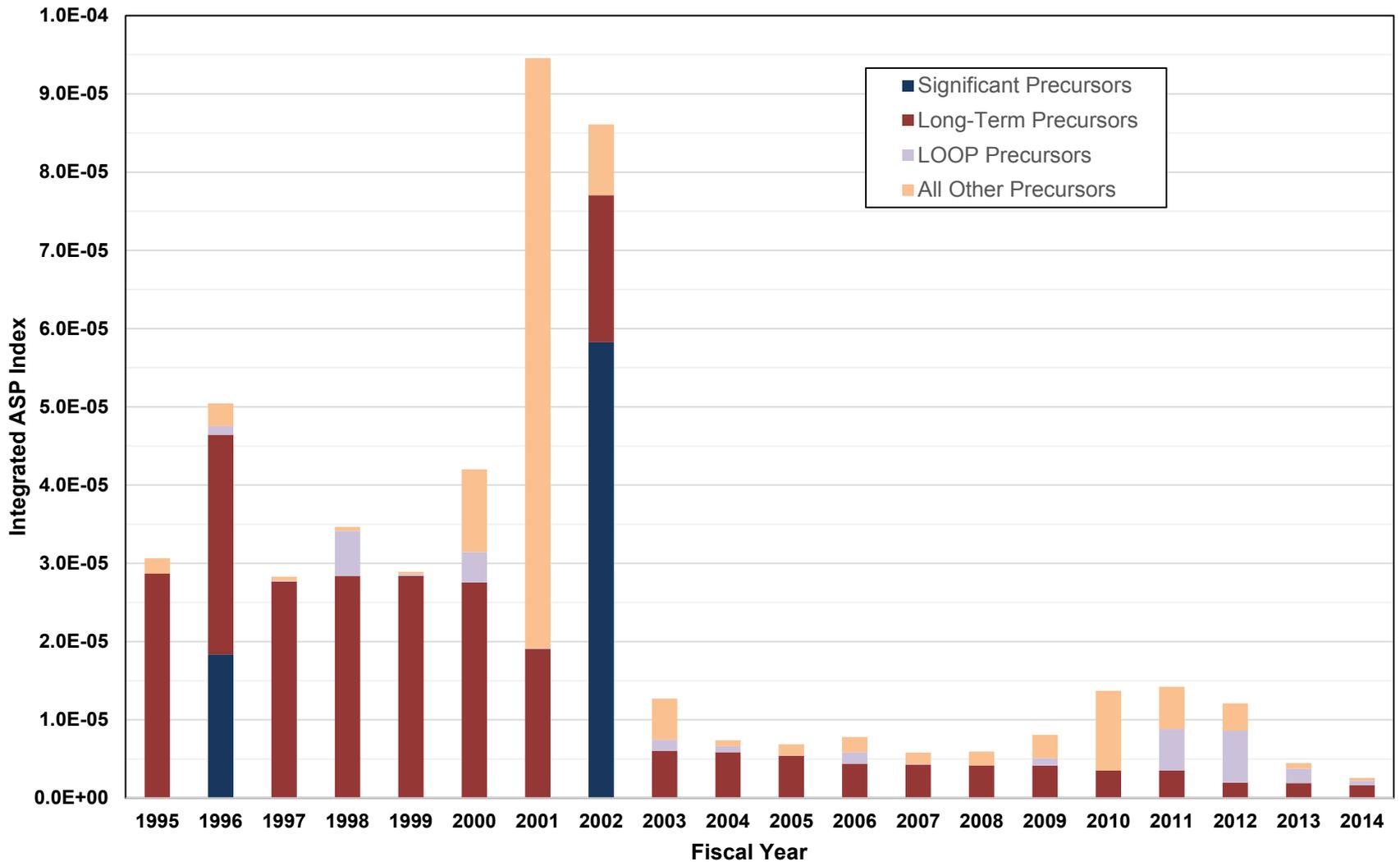


Supplemental Information

Historical ASP Results



Integrated ASP Index



Integrated ASP Index (cont.)

- Provide for order-of-magnitude comparisons with industry-average CDF estimates derived from licensee PRAs and the NRC's SPAR models.
 - Index (or CDF) from precursors for a given fiscal year (FY) is the sum of CCDPs in the FY divided by the number of reactor-calendar years.
 - The risk contribution of a precursor is included for the entire duration that the condition existed.
 - The risk contributions from precursors involving initiating events are included in the FY that the event occurred.

- **Insights Gained**
 - Based on order of magnitude, the average integrated ASP index during the FY 2005–2014 period is consistent with the CDF estimates from the SPAR models and the licensees' PRAs.
 - A review of the ASP index for the past 20 years reveals the following:
 - The two significant precursors contribute approximately 15% of the total risk due to all precursors.
 - Precursor due to long-term degraded conditions contribute approximately 51% of the total risk due to all precursors.
 - LOOP precursors contribute approximately 6% of the total risk due to all precursors.

ASP Process Diagram

