



KENEXIS

Designed for Safety, Security & Reliability

Unified Hazard Assessment

Bringing Together HAZOP, LOPA, Hazard Registers
and Bowtie in a Unified Data Structure



SAFETY
INSTRUMENTED
SYSTEMS

Introduction

- PHA was initially “check the box” – minimum compliance and minimum cost
- Value found in PHA information, expanded to other purposes
 - LOPA – for SIS safety integrity levels
 - Hazard Registers – tracking and understanding of significant hazard scenarios
 - Bowtie diagrams – Visualization of hazard scenarios
- Maximizing usefulness of data developed during PHA will require changes in data structure and practices

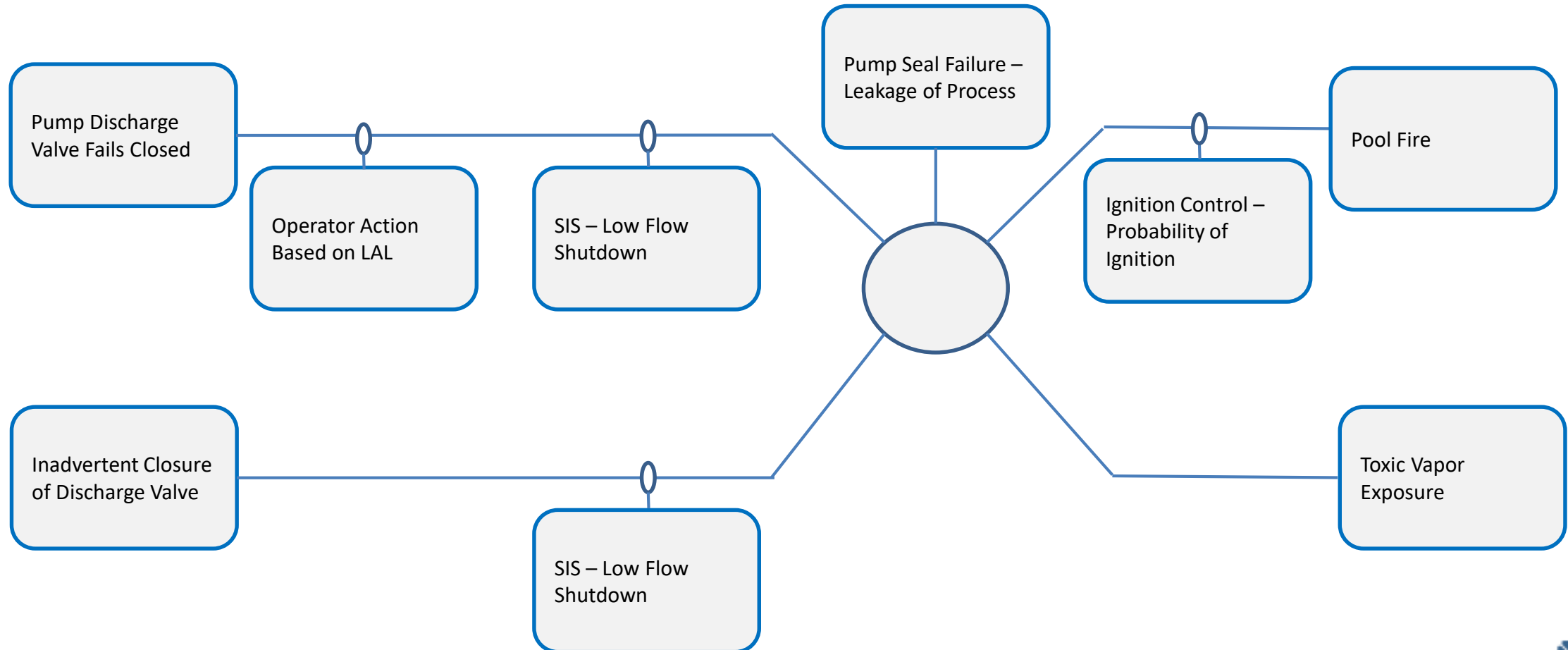
Extending PHA to LOPA

- LOPA increases precision for significant hazards
- LOPA increases scrutiny of effectiveness of safeguards
 - Separately considers initiating events and safeguards
 - Assesses effectiveness of safeguards
- PHA and LOPA should be consistent in terms of consequence and listed safeguards
- LOPA extends analysis

Bowties Visualize Hazard Scenarios

- Graphical representation
 - Multiple Causes
 - Multiple Consequences
- Bowtie “knot” is loss of containment (process industries)
- Shows in a single diagram all causes, consequences, and factors influencing risk
- Hazard Register entries are simplified LOPA scenarios can be visualized with Bowtie

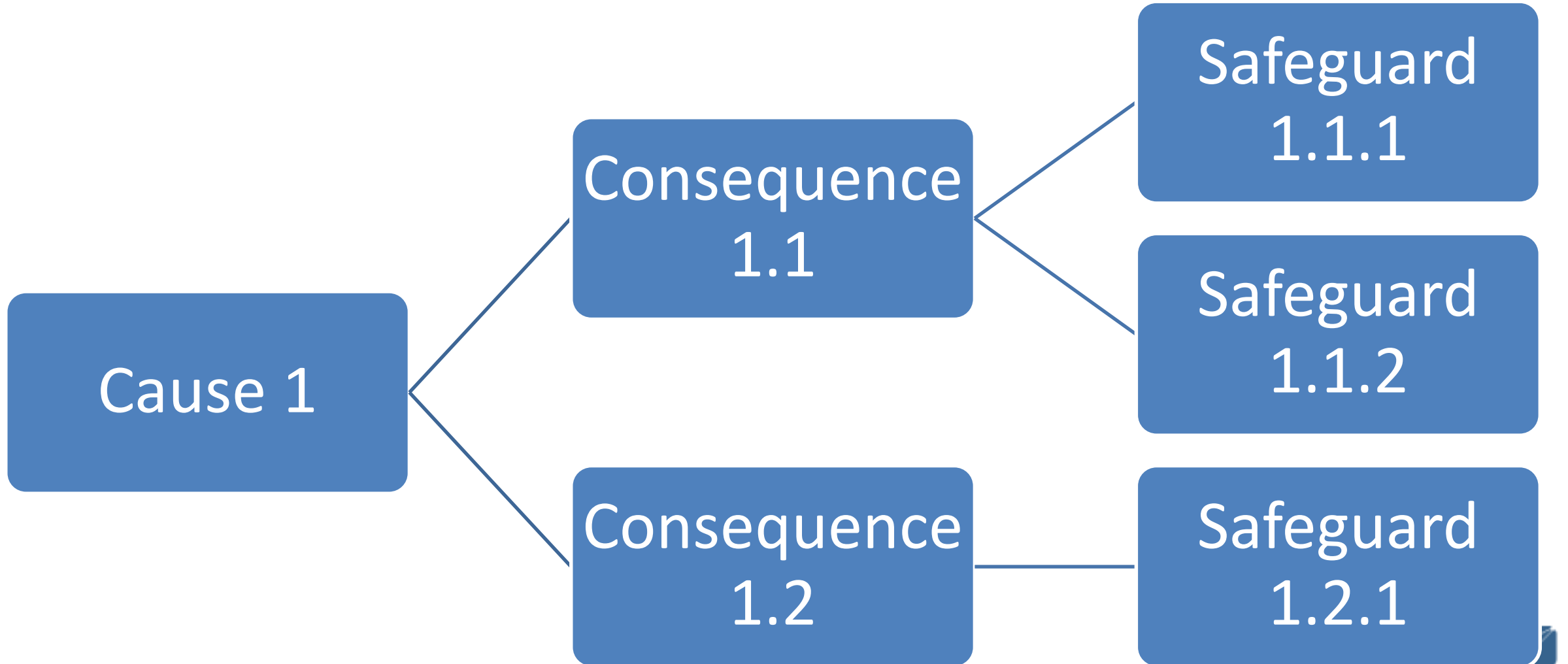
Bowtie Diagram



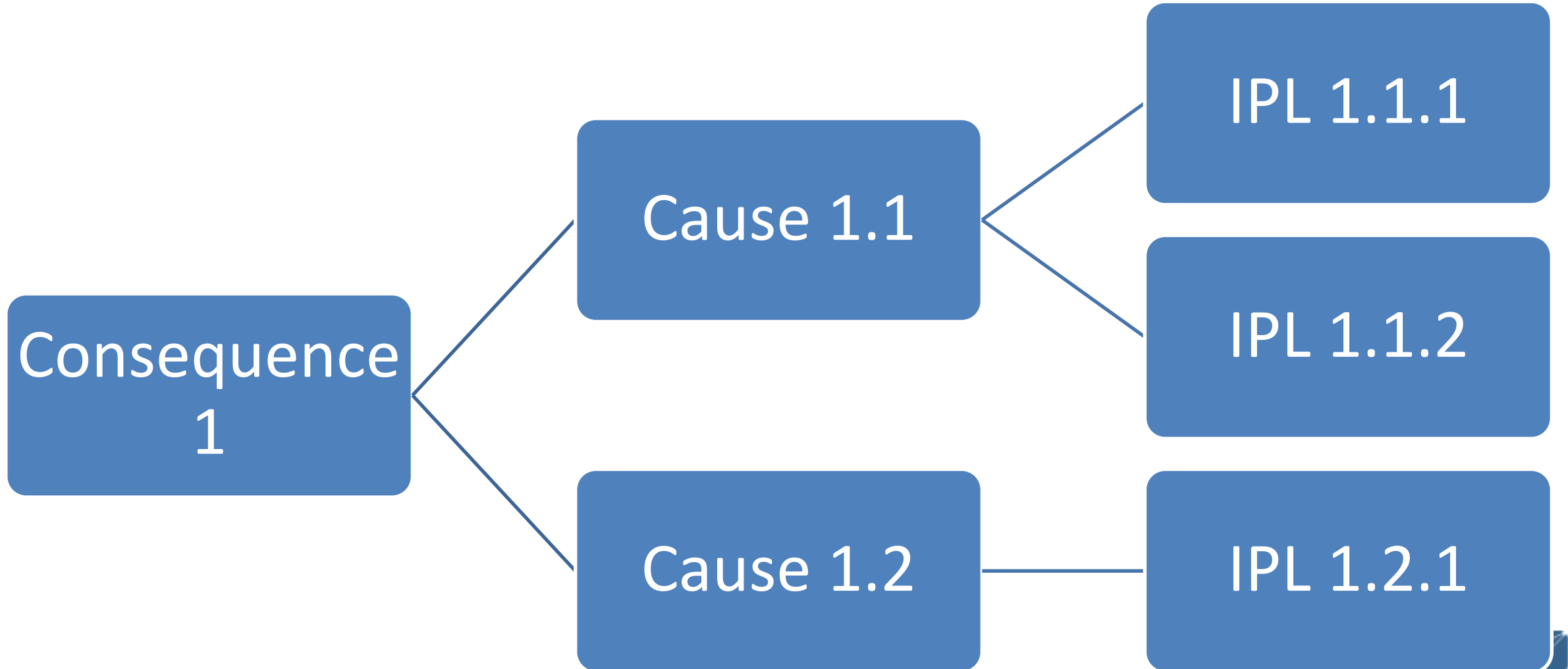
Problems with Existing PHA Documentation

- Scenarios documented in improper location
 - “cause local – consequence global” results in cause-indexing
 - Scenario documented where cause occurs
- Subsequent studies generally interested in hazard scenario
- LOPA studies are optimized by consequence indexing
 - LOPA – for SIS safety integrity levels
- Everything is documented in the flow deviation
 - “Poor Man’s FMEA”
- Multitude of different file formats at a single facility

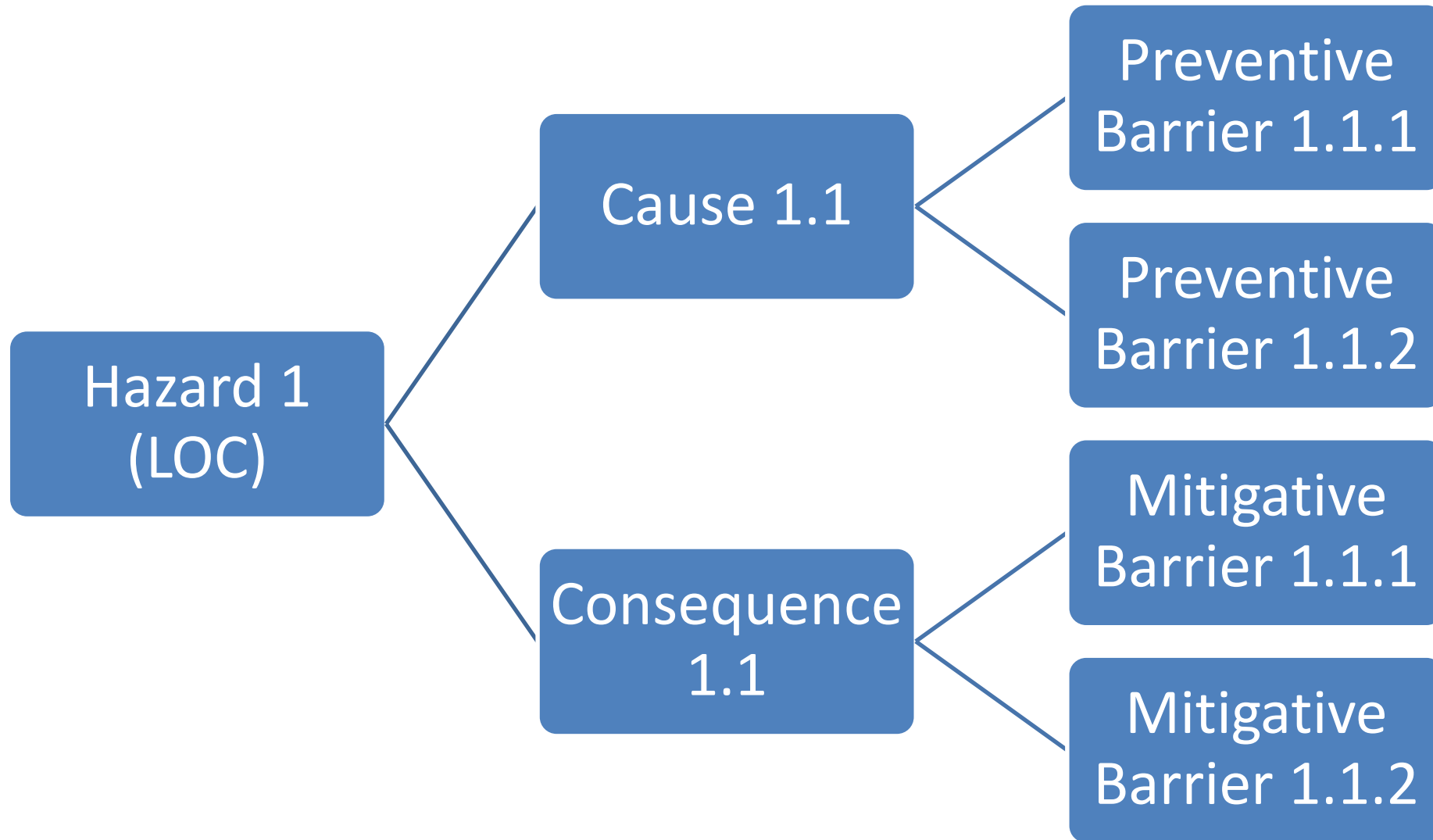
Typical PHA – Cause Indexed



Typical LOPA – Consequence Indexed



Bowties – Hazard Indexed



Unified Hazard Assessment Data Structure - Fields

- Define and standardized all fields used in hazard assessment
- Super-set Concept – Customizable View
- Subject of Research at P2SAC

Deviation	Cause	Consequence	CAT	S	L	RR	S	L	RR
				Before Safeguards	Before Safeguards	Before Safeguards			
1.1 High Pressure	1.1.1 Outlet pressure control valve fails to the closed position	1.1.1.1 Increase in drum pressure up to the dead head pressure of the pump. This pressure is 150% of the MAWP of the vessel, and as such damage to connections and appurtenance to the vessel are expected to fail, causing loss of containment with the potential for toxic	S ▼	▼	▼		H ▼	M ▼	3

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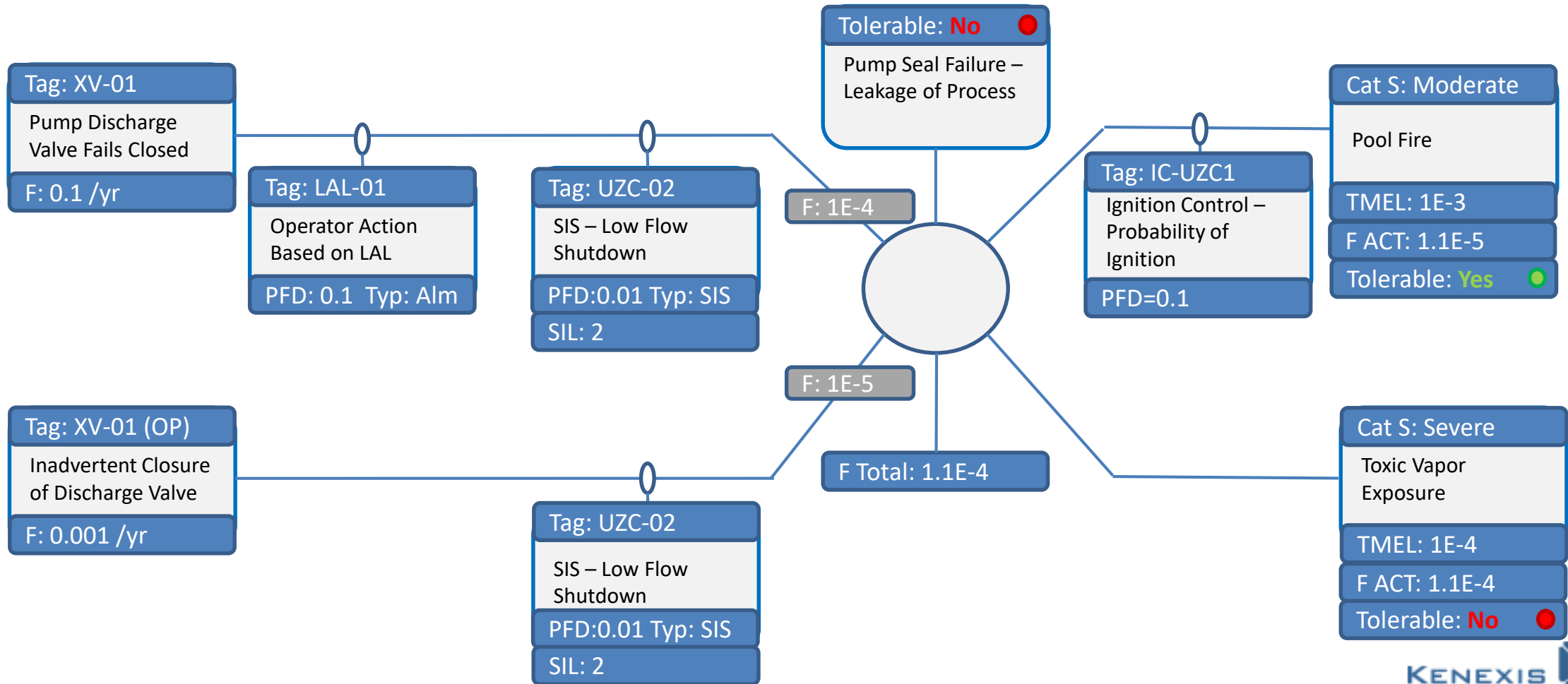
Consequences

- Consequence
- Likelihood Before Safeguards
- Risk Ranking Before Safeguards
- Likelihood
- Risk Ranking
- LOPA Required
- PHA Recommendations
- PHA Comments
- Lopa Recommendations
- Lopa Comments
- Consequence Category
- Consequence Severity Before Safeguards

UHA Implementation and Benefits

- PHA (HAZOP)
 - New key field of hazard scenario must be documented
 - Workflow changed to document at hazard scenario, not cause
 - Subset of fields optimized for PHA
- LOPA
 - Each PHA scenario includes flag indicating inclusion in LOPA
 - LOPA worksheet filtered to only show flagged scenarios
 - Fields displayed expanded to include LOPA specific information, which is expanded upon existing PHA information, not re-created
- Hazard Register
 - Flagged high risk PHA scenarios – limited fields displayed

UHA Implementation and Benefits - Bowtie

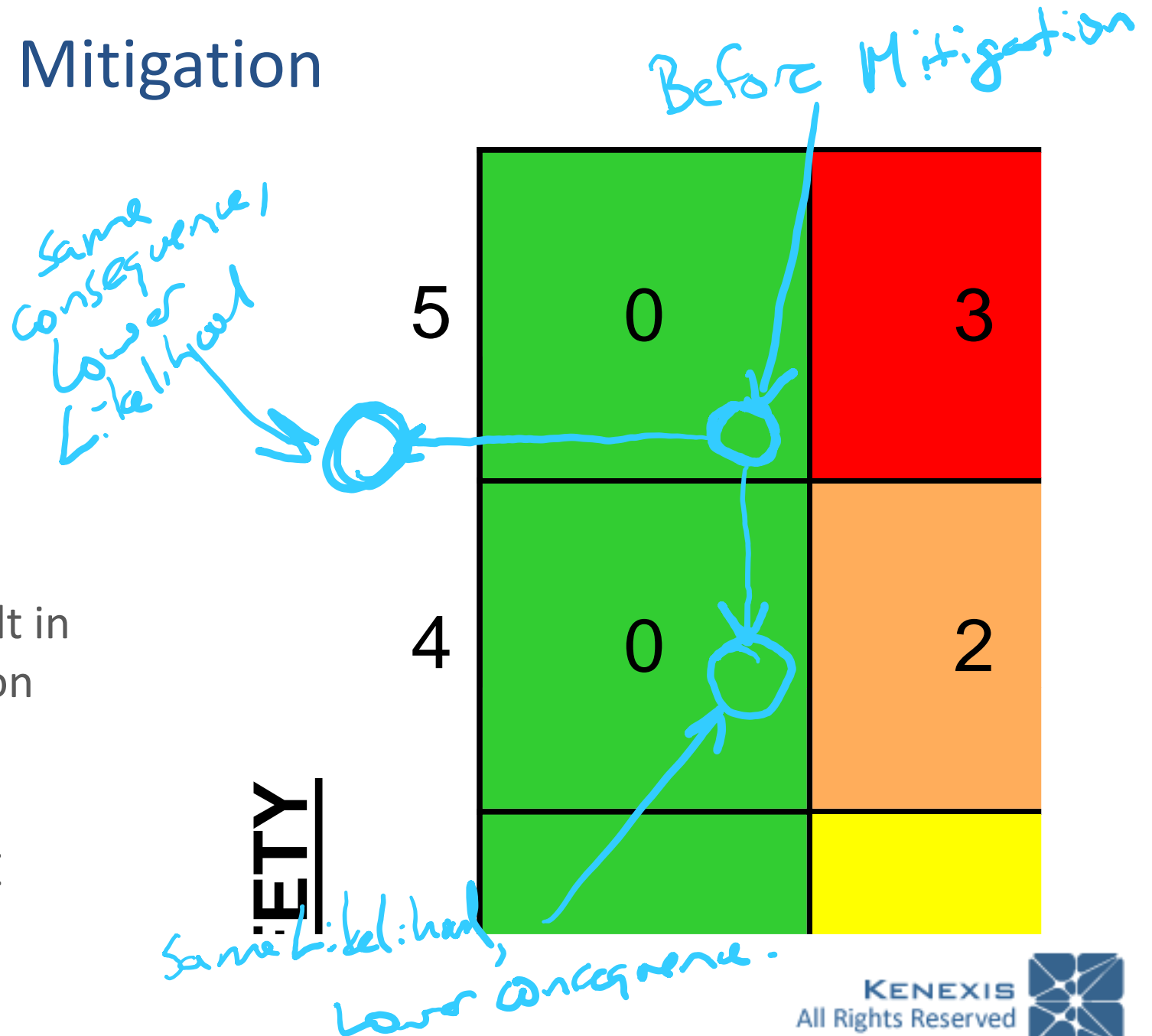


UHA – Future Development

- Handling of Mitigative Safeguards
 - Mitigative safeguards operate after loss of containment
 - In LOPA, referred to as conditional modifiers
 - Currently only usable if when successful mitigate consequence to zero
 - Many mitigative safeguards leave significant residual consequence
 - Mitigative safeguards could include consequence category if successful
 - Requires tracking of multiple targets for different consequence categories

Effect of Consequence Mitigation

- A tank dike is used as a mitigative barrier
 - Successful operation could result in a flash fire with moderate injury
 - Lower Severity
 - Higher Likelihood
 - Failed operation could result in a large vapor cloud explosion
 - Higher Severity
 - Lower Likelihood
 - BOTH OUTCOMES MUST BE TRACKED



Conclusions

- PHA data desired to be used for other purposes
- Current methods and data structures will not allow it
- Use of internet data structures and communication techniques will improve usability of PHA data
- Unified Hazard Analysis Data structure will standardize data and allow use for multiple purposes