SPRING24 +20TH GCPS

A Joint AIChE and CCPS Meeting

March 24–28, 2024

New Orleans Ernest N. Morial Convention Center
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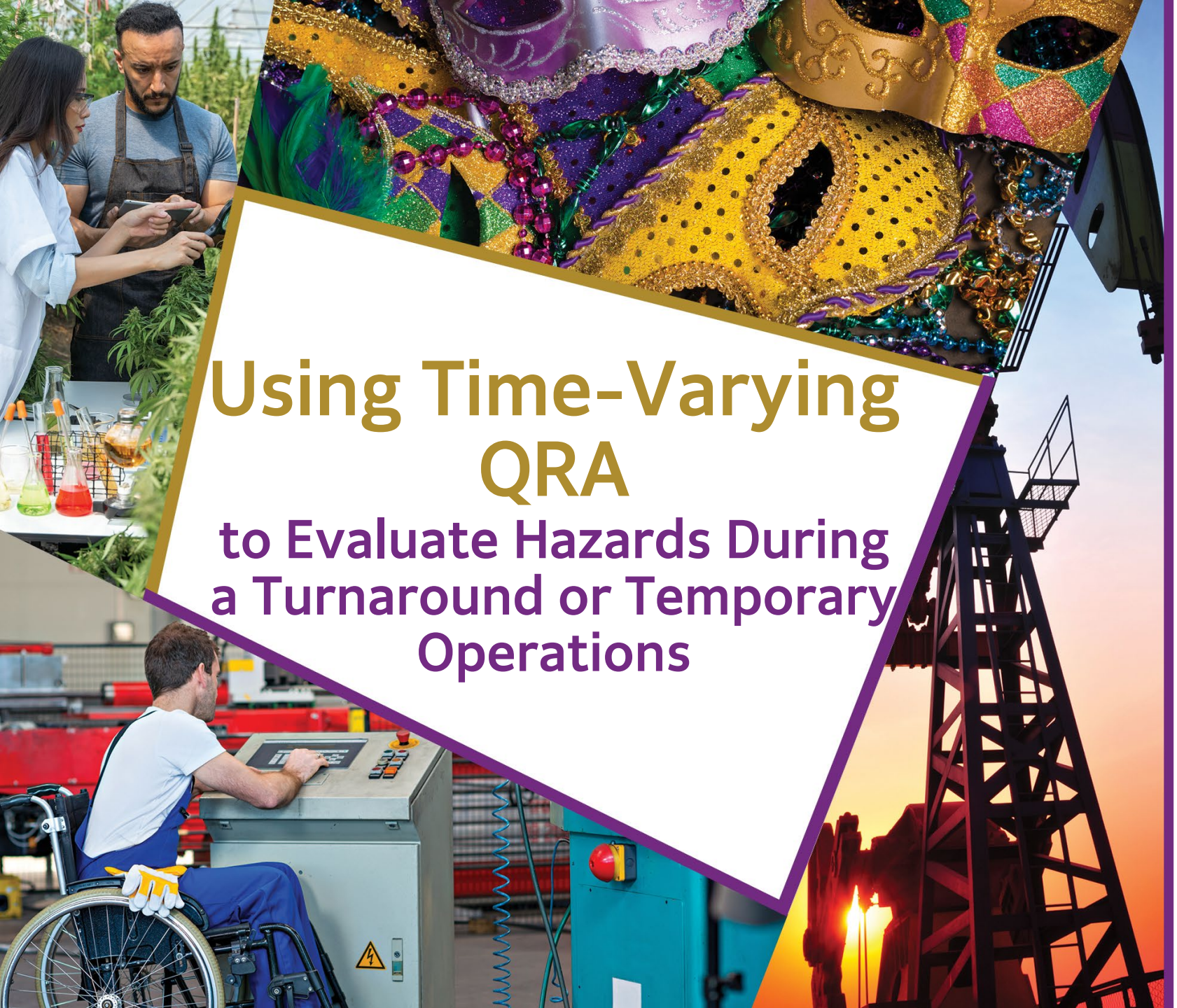

Using Time-Varying QRA

to Evaluate Hazards During a Turnaround or Temporary Operations

Presenter:
Colin D Armstrong - Principal Engineer & Group Lead - Quantitative Risk
AcuTech Group, Inc.

Authors:
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Tuesday, March 26, 2024

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Colin D Armstrong

- Technical Lead for hundreds of FSS and QRA projects in oil, gas, LNG, and specialty chemical industries worldwide
- Instructor for QRA and Consequence Modeling for operating companies and University students
- Extensive experience in Process Hazard Analysis
- Investigator and expert witness in response to incidents and OSHA citations
- AcuTech since 2012

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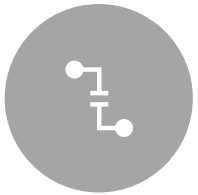
QRAs Are Widely Applied for Normal Operating (Static) Risks

- Quantify risks to
  - People
    - onsite, offsite, occupied buildings
  - Environment
  - Business
- Do Not Generally Address
  - S/U and S/D
  - SIMOPS
  - Turnarounds
  - Maintenance
  - Construction

Accidents Occur 5x More Often During Abnormal Operations[1]

Increased risk of process upsets, due to temporary modifications to equipment, process conditions, and procedures.



Increased risk of misalignment or human error as part of shutdown, isolation, de-inventory, maintenance, and startup activities due to the complexity of work scope.

Increased risks from external factors (e.g., adjacent work activities, vehicle traffic, lifting devices).

Increased intensity and stress on workers.

Increased numbers of workers present in and around hazardous process areas.

Increased use of temporary occupied structures.

1 CCPS. Guidelines for Safe Process Operations and Maintenance. 1995

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Normal Operations (Static) QRAs Can Evaluate Abnormal (Dynamic) Operations with a Straightforward Approach

Topics:

- A method to develop a Dynamic QRA using DNV Safeti
- An example QRA assessing the risk profile of a Turnaround (T/A) with complex integrated process operations, including Startup (S/U) and Shutdown (S/D)

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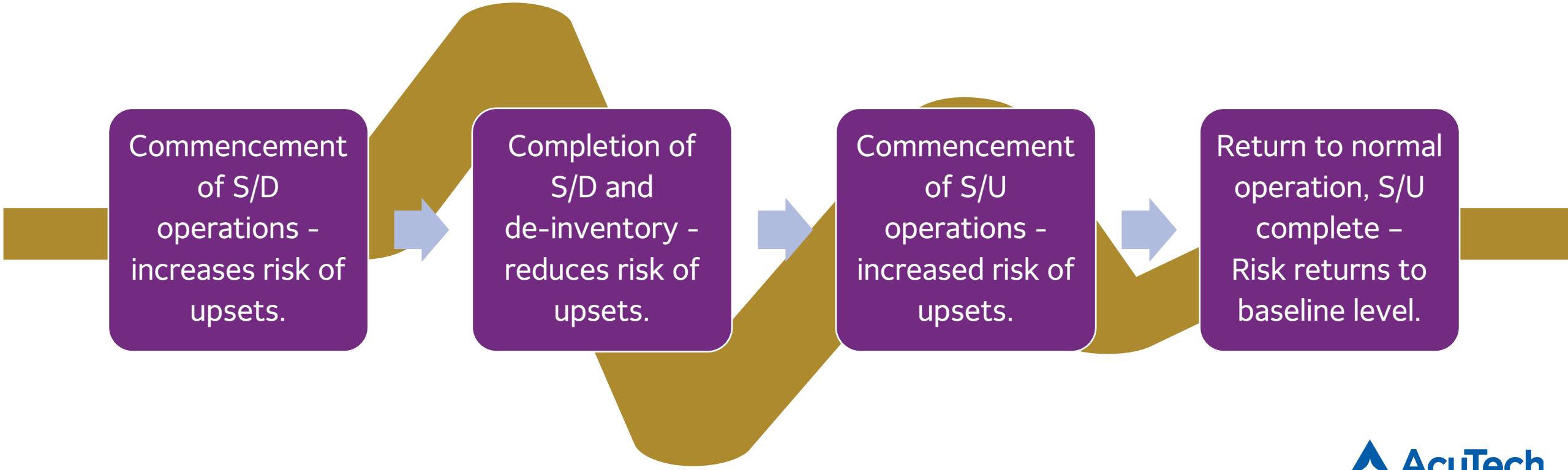
Defining the Scope

- dependent on the operation being planned (T/A, SIMOPS, Expansion)
- S/U, S/D, and maintenance/construction activities are staged over a period of time
- define the distinct operating/risk time periods for the operation

Consider the Risks



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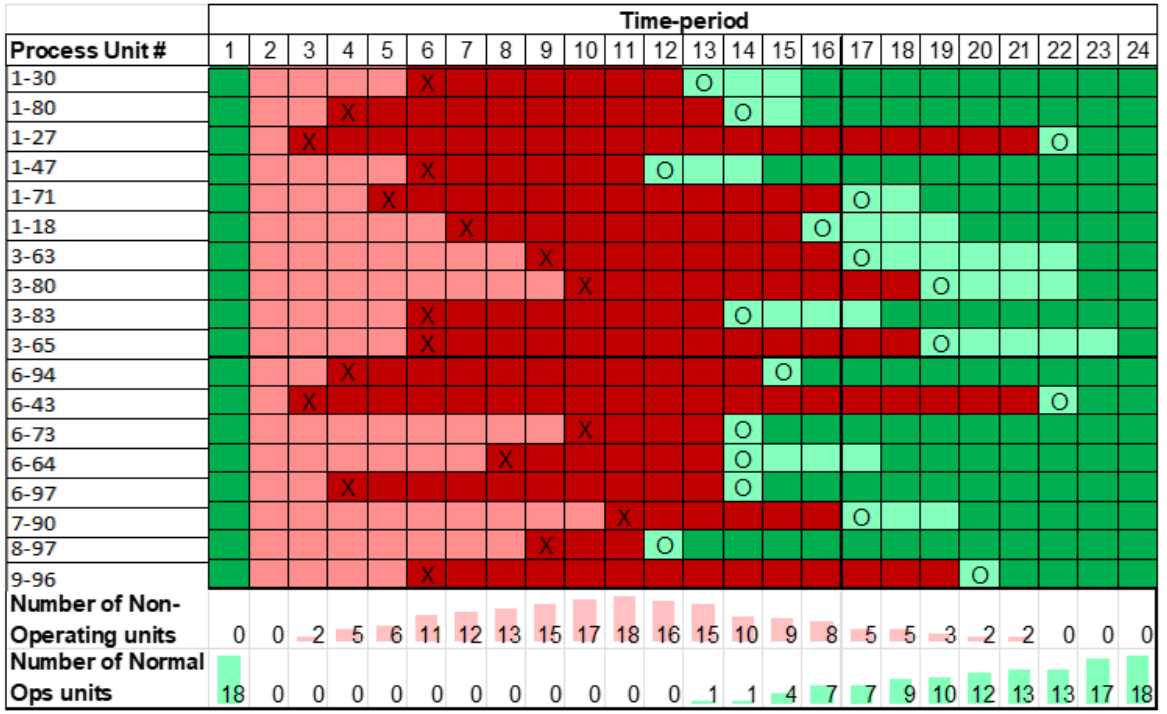
Case Study- A Multi-Unit T/A

- S/D and S/U operations for multiple units must be considered
- Time periods do not refer to specific dates, but rather milestones
  - e.g. Units 3-63 & 6-73 S/D complete



	Time-period																							
Process Unit #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1-30						X							O											
1-80				X										O										
1-27			X																			O		
1-47						X						O												
1-71					X												O							
1-18							X									O								
3-63									X								O							
3-80										X									O					
3-83						X								O										
3-65						X													O					
6-94				X											O									
6-43			X																			O		
6-73										X				O										
6-64								X						O										
6-97				X										O										
7-90											X						O							
8-97									X			O												
9-96						X														O				
Number of Non-Operating units	0	0	2	5	6	11	12	13	15	17	18	16	15	10	9	8	5	5	3	2	2	0	0	0
Number of Normal Ops units	18	0	0	0	0	0	0	0	0	0	0	0	1	1	4	7	7	9	10	12	13	13	17	18

Color coding		Description
Normal ops		Unit operates normally
Online starts	O	Start-up operations start on unit
Online		Start-up operation are being carrierd on the unit
Shutdown		Shut-down operations are being carried on the unit
Offline starts	X	Unit stops to operate
Offline		Unit is not operating

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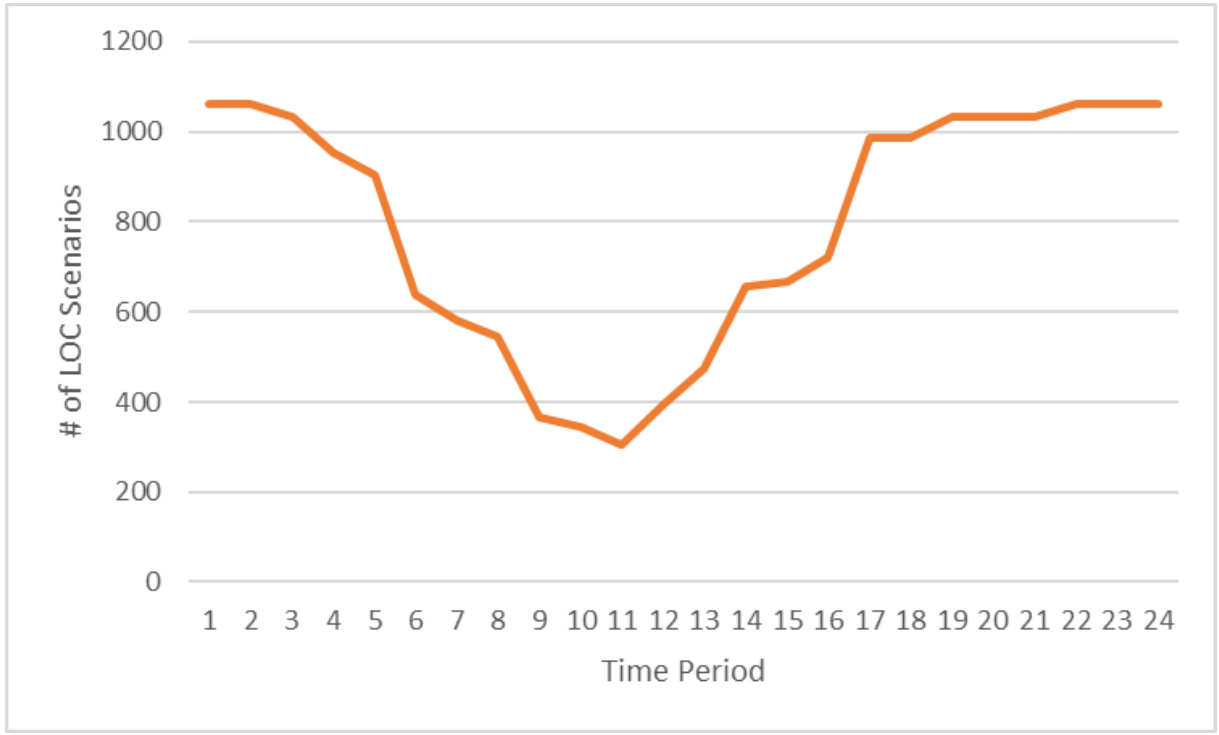
Case Study- A Multi-Unit T/A

- A T/A will result in hazards being removed as units S/D, then returning as units start up
- Units that are S/D still present areas of obstruction for VCE risks
- Units in operation during this period still present hazards and risks may be increased during this period
- The dynamic risk profile is dependent on the specific operation plan



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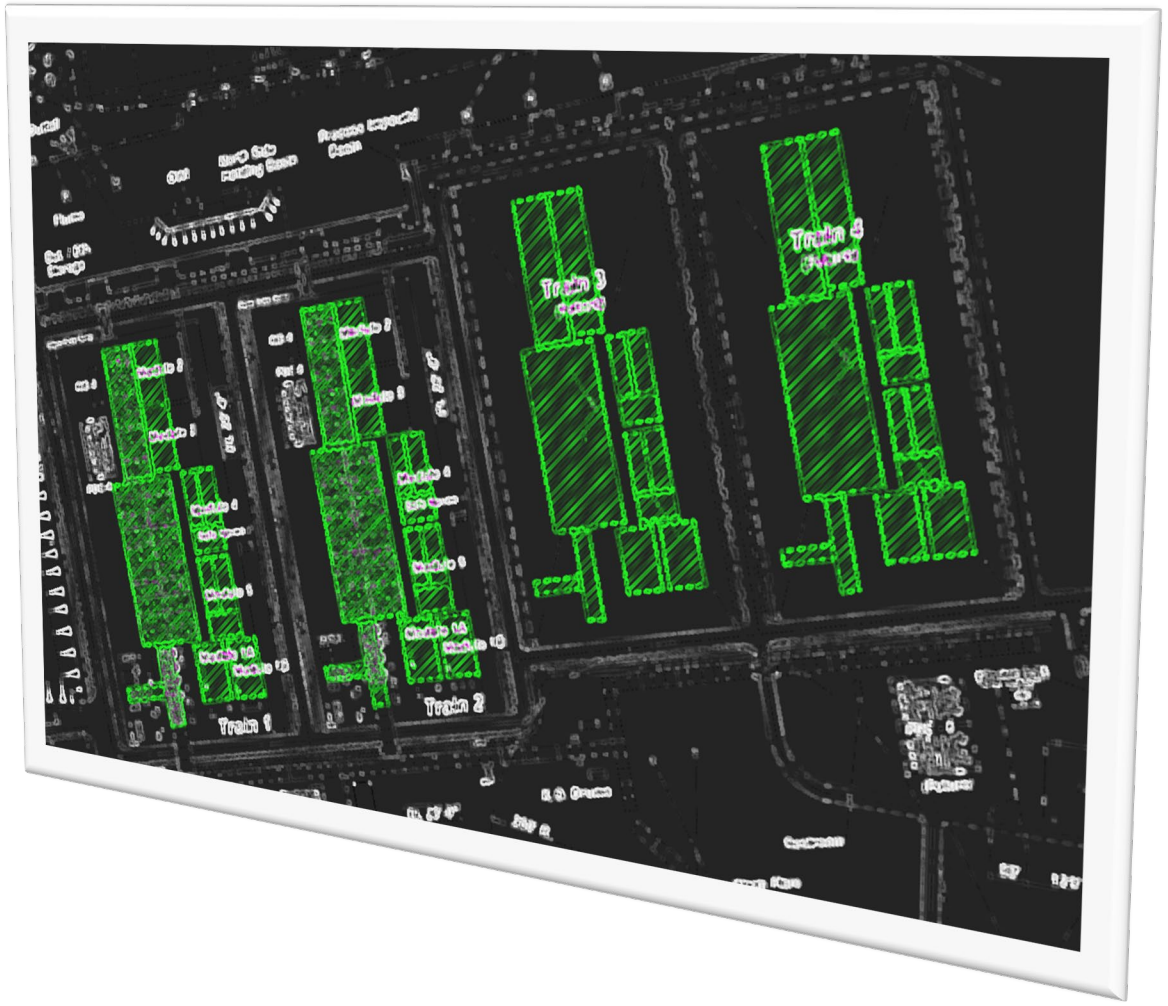
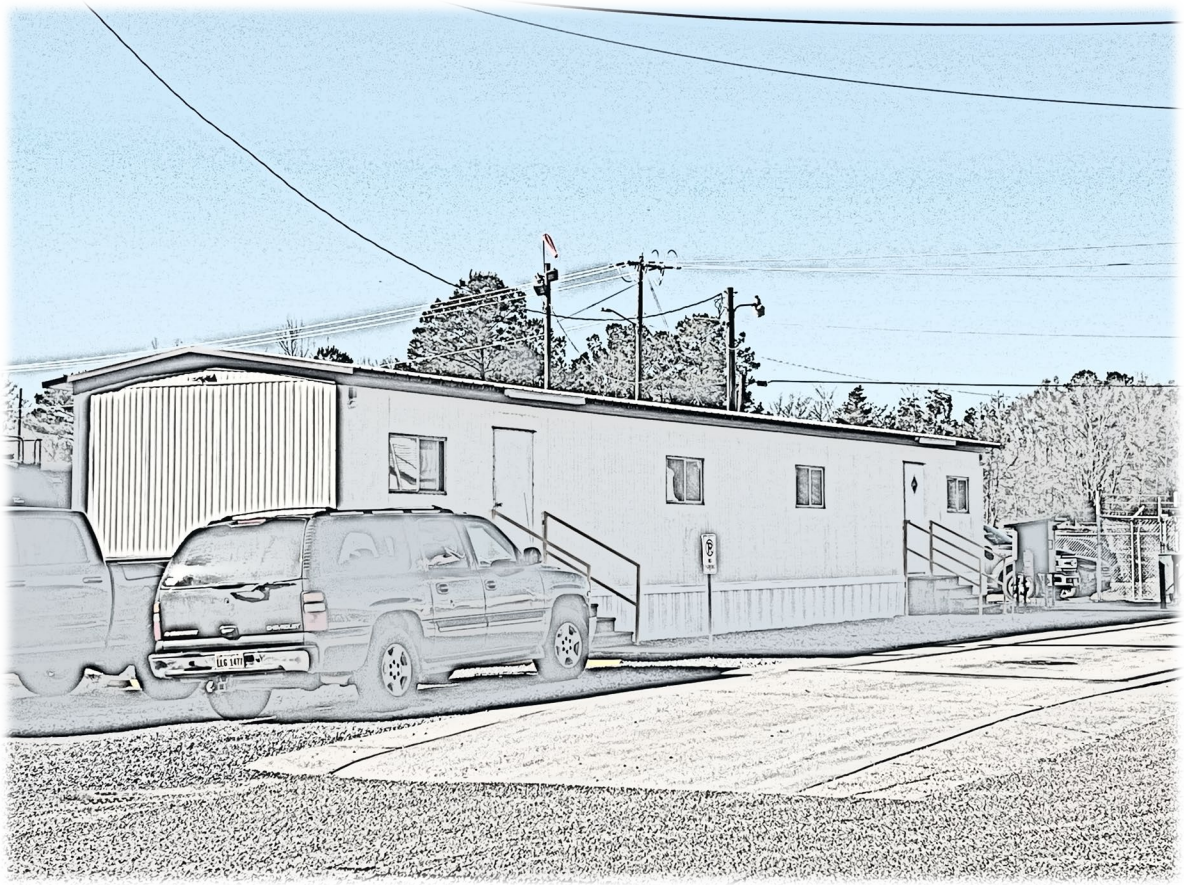
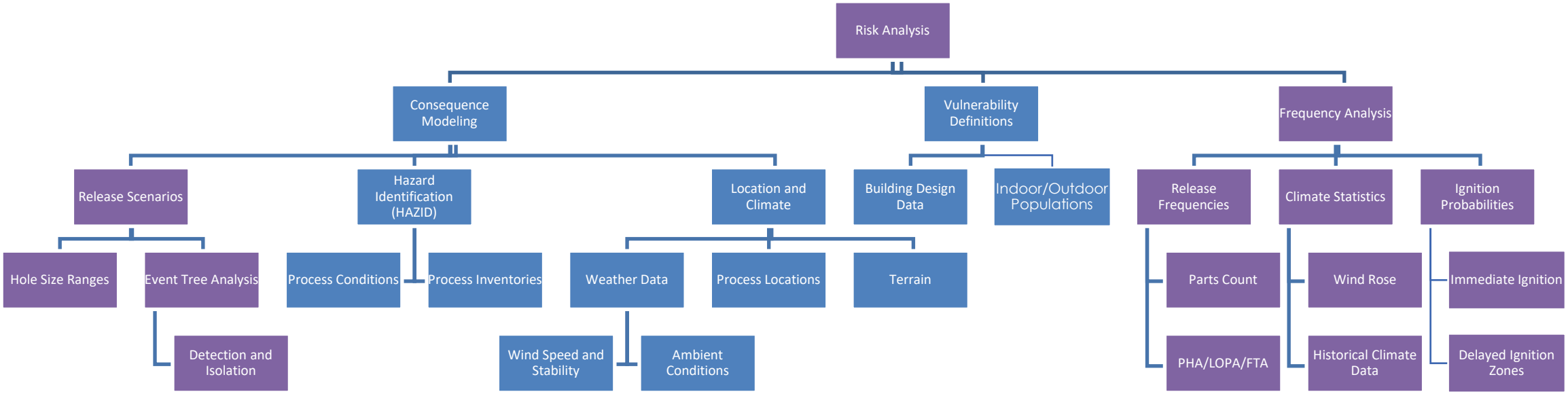


- Identify potential mobilization areas for workers
- Define when essential workers must be onsite
- Define the proposed temporary structures and vulnerability criteria
- Consider special requirements for light wood trailers and non-essential personnel under API RP 753



- The Safeti risk model evaluates the individual and aggregate risks
- Inputs Include:
  - LOCs, Locations, and Frequencies
  - Immediate Ignition Probabilities

- Delayed Ignition Zones
- Obstructed Regions
- Weather/Wind Conditions & Probabilities
- Populations
- Terrain



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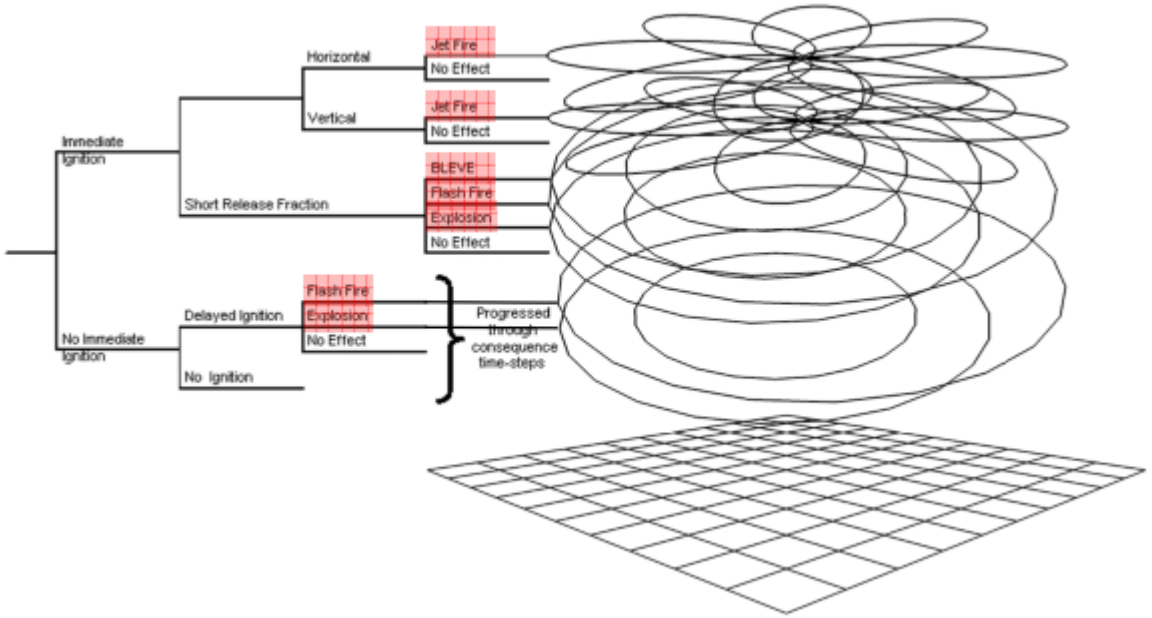

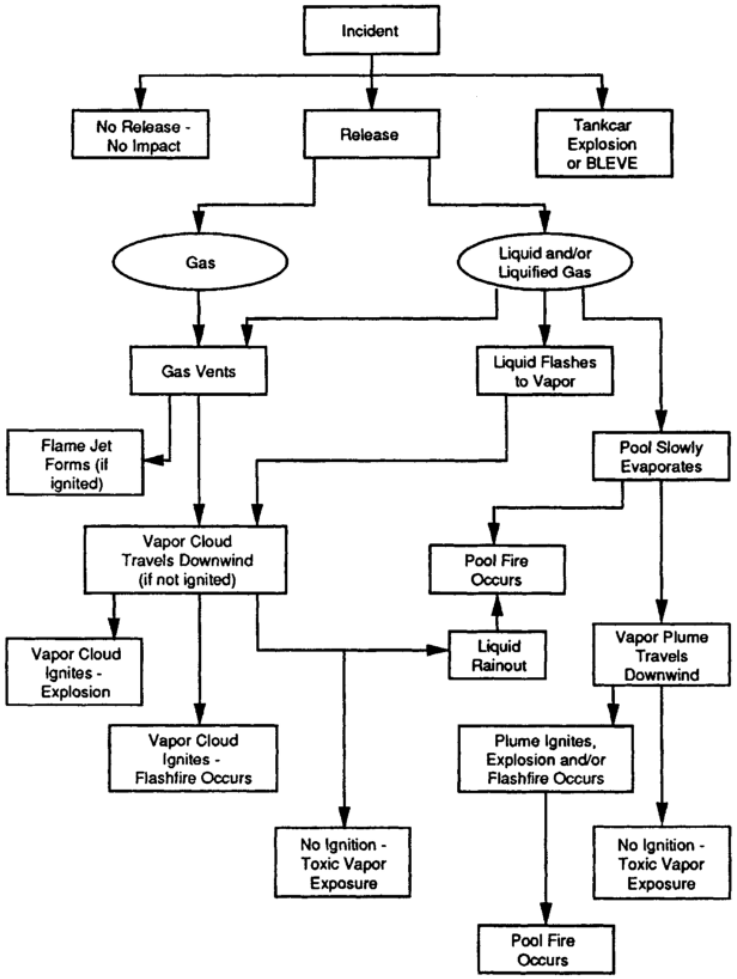

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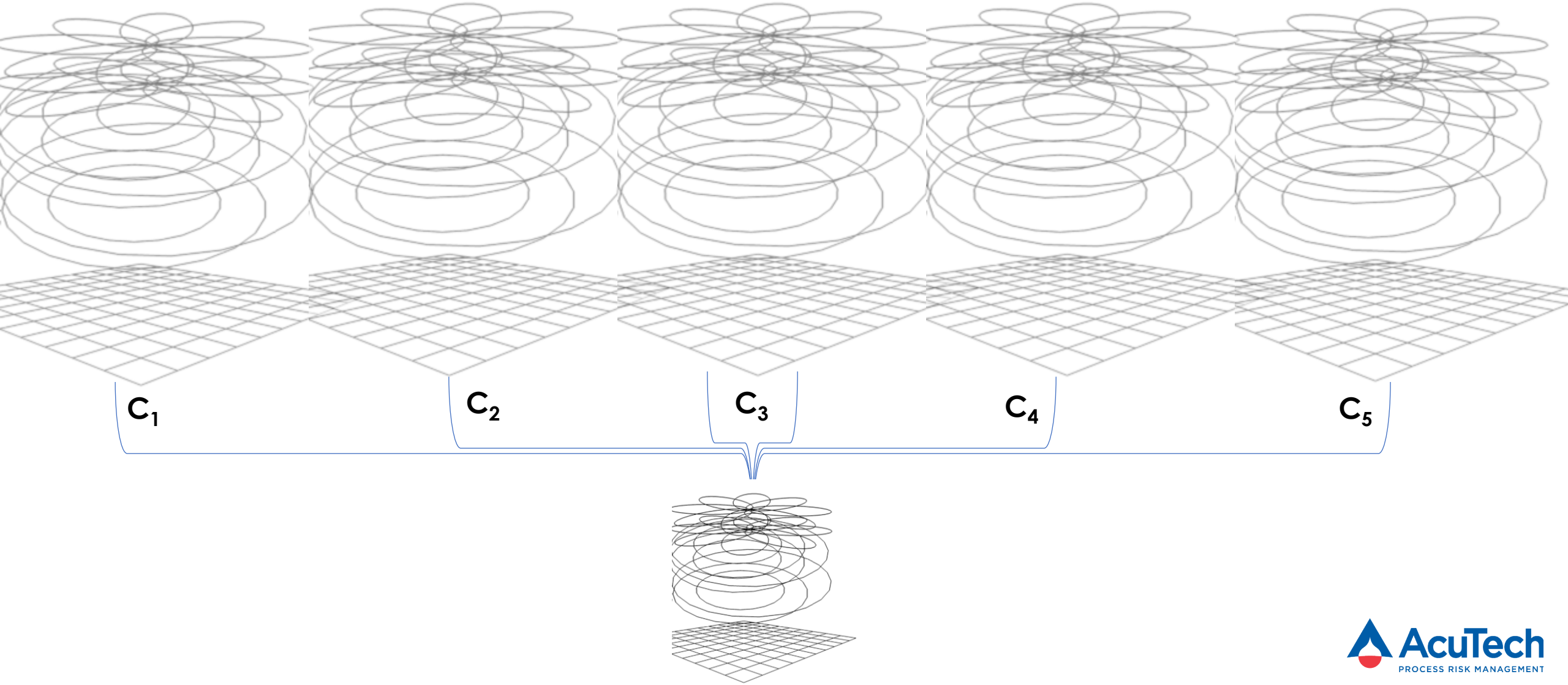

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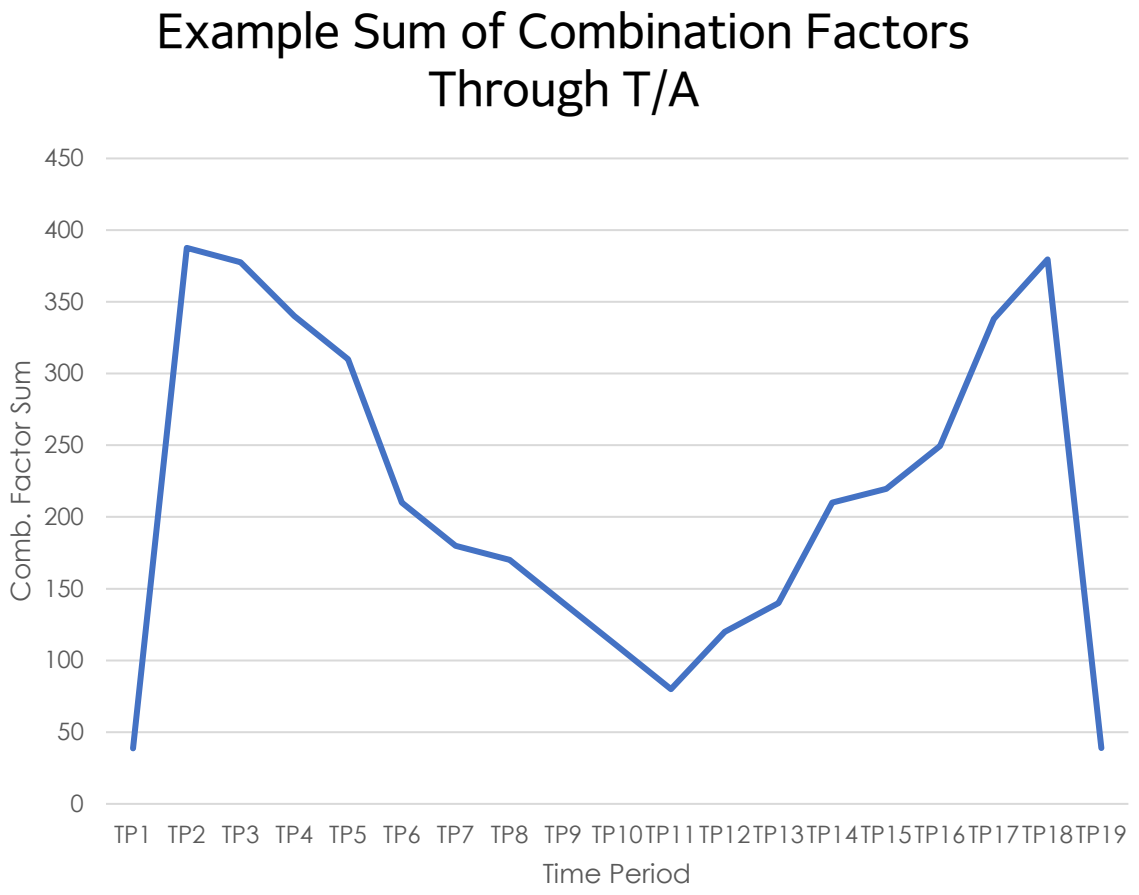
- Run rows and the combinations matrix modify a static QRA into a dynamic QRA
- The result will be that the number of run rows in the study will be multiplied
- In our T/A example
  - each process unit is separated into its own unique run row(s)
  - expanded from 28 to 78 run rows

Unit	Day Night	Hazard Type	Confined Unconfined	TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8	TP9	TP10	TP11	TP12	TP13	TP14	TP15	TP16	TP17	TP18	TP19
Unit 13	Day	FLAM	Open	0.4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0.4
Unit 13	Night	FLAM	Open	0.6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0.6
Unit 13	Night	FLAM	Open	0.6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0.6
Unit 13	Day	FLAM	Open	0.4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0.4
Unit 7	Day	FLAM	Open	0.4	4	4	4	4	0	0	0	0	0	0	0	4	4	4	4	4	4	0.4
Unit 7	Night	FLAM	Open	0.6	6	6	6	6	0	0	0	0	0	0	0	6	6	6	6	6	6	0.6
Unit 7	Day	TOXIC and FLAM	Open	0.4	4	4	4	4	0	0	0	0	0	0	0	4	4	4	4	4	4	0.4
Unit 7	Night	TOXIC and FLAM	Open	0.6	6	6	6	6	0	0	0	0	0	0	0	6	6	6	6	6	6	0.6
Unit 3	Day	FLAM	Open	0.4	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	6	0.6
Unit 3	Night	FLAM	Open	0.6	6	6	6	6	0	0	0	0	0	0	0	0	0	0	0	0	6	0.6
Unit 6	Day	FLAM	Open	0.4	4	4	4	4	4	4	4	4	0	0	0	0	0	0	0	0	3	0.3
Unit 6	Day	FLAM	Open	0.4	4	4	4	4	4	4	4	4	0	0	0	0	0	0	0	0	3	0.3
Unit 2	Day	FLAM	Open	0.4	4	4	4	4	4	4	4	4	4	0	0	0	0	0	0	3	3	0.3
Unit 2	Day	FLAM	Confined	0.4	4	4	4	4	4	4	4	4	4	0	0	0	0	0	0	3	3	0.3
Unit 6	Day	FLAM	Open	0.4	4	4	4	4	4	4	4	4	4	0	0	0	0	0	0	3	3	0.3
Unit 6	Night	FLAM	Open	0.6	6	6	6	6	6	6	6	6	6	0	0	0	0	0	0	0	6	0.6
Unit 6	Night	FLAM	Open	0.6	6	6	6	6	6	6	6	6	6	0	0	0	0	0	0	0	6	0.6
Unit 2	Night	FLAM	Open	0.6	6	6	6	6	6	6	6	6	6	6	0	0	0	0	0	6	6	0.6
Unit 2	Night	FLAM	Confined	0.6	6	6	6	6	6	6	6	6	6	6	0	0	0	0	0	6	6	0.6
Unit 6	Night	FLAM	Open	0.6	6	6	6	6	6	6	6	6	6	6	0	0	0	0	0	6	6	0.6
Unit 4	Day	FLAM & TOX	Open	0.4	4	4	4	4	4	4	0	0	0	0	0	0	4	4	4	4	4	0.4
Unit 4	Day	FLAM & TOX	Open	0.4	4	4	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	0.4
Unit 4	Night	FLAM & TOX	Open	0.6	6	6	6	6	6	6	0	0	0	0	0	0	6	6	6	6	6	0.6

- For each time period, combination factors are adjusted to account for the increase or decrease in risk contribution
- Risk may increase across multiple units during S/D of a single unit
- Consider the magnitude and scope of the risk factors to be applied for the operation



Considerations under API 753 Second Edition, 2024

- Within 330’ of the hazard source (e.g., congested volume or source for a fire/flammable release), nonessential personnel **shall** not be assigned.
- The risk-based approach **shall** not be used to site LWTs or nonessential personnel in a portable building in Zone 1.
- The following requirements **shall** be used for siting portable buildings regardless of the method used (Zoning Method A or B).

Zone Number	Light Wood Trailers	Portable Buildings Other Than Light Wood Trailers	Occupancy Restrictions
Zone 1	Not Allowed	Siting Evaluation Required	House Only Essential Personnel
Zone 2	Siting Evaluation Required	Siting Evaluation Required	See Section 6 for Restrictions
Zone 3	No Restrictions	No Restrictions	See Section 6 for Restrictions

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Considering Risk Criteria

- Should Transitory Risks be More Acceptable than Baseline Risks?
- Individual risk and societal risk are generally presented as risk per annum

- API RP 753 2nd Ed. States
  - When evaluating individual risk, “No credit shall be taken for cases where the building will not be used or located at the site for less than a year”

Considering Risk Criteria

- Should Transitory Risks be More Acceptable than Baseline Risks?
- Individual risk and societal risk are generally presented as risk per annum

- API RP 753 2nd Ed. States
  - For societal risk calculations, operators may account for the limited duration of the non-routine operation, which contributes only a portion to the site's annualized aggregate risk

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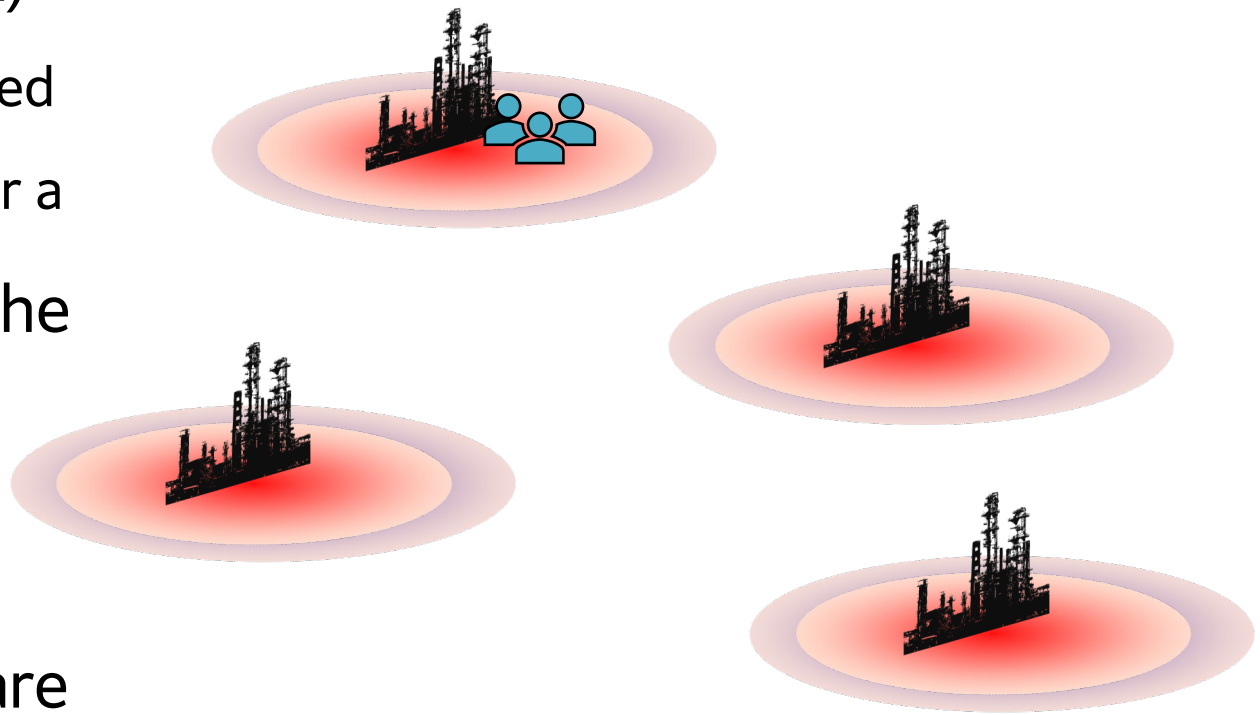
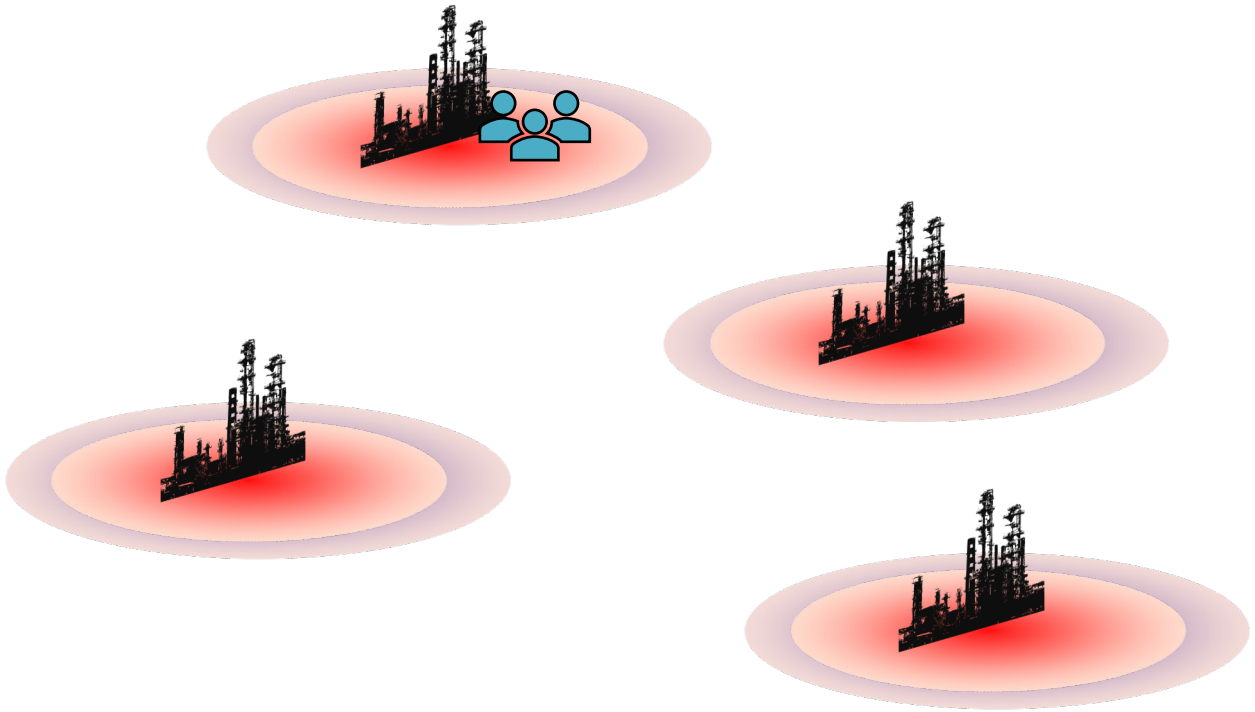
- Location specific individual risk (LSIR)
  - Expressed as a predicted likelihood of impacts by a fatal hazard on an annualized basis
  - Risk to a person present at a location for a year
- The risk measure is also expressing the instantaneous risk exposure to a person in a location at a moment in time
- LSIR for a worker is not affected by the time they are present
- Permanent and temporary workers are both exposed to the same risk levels at any moment in the same location

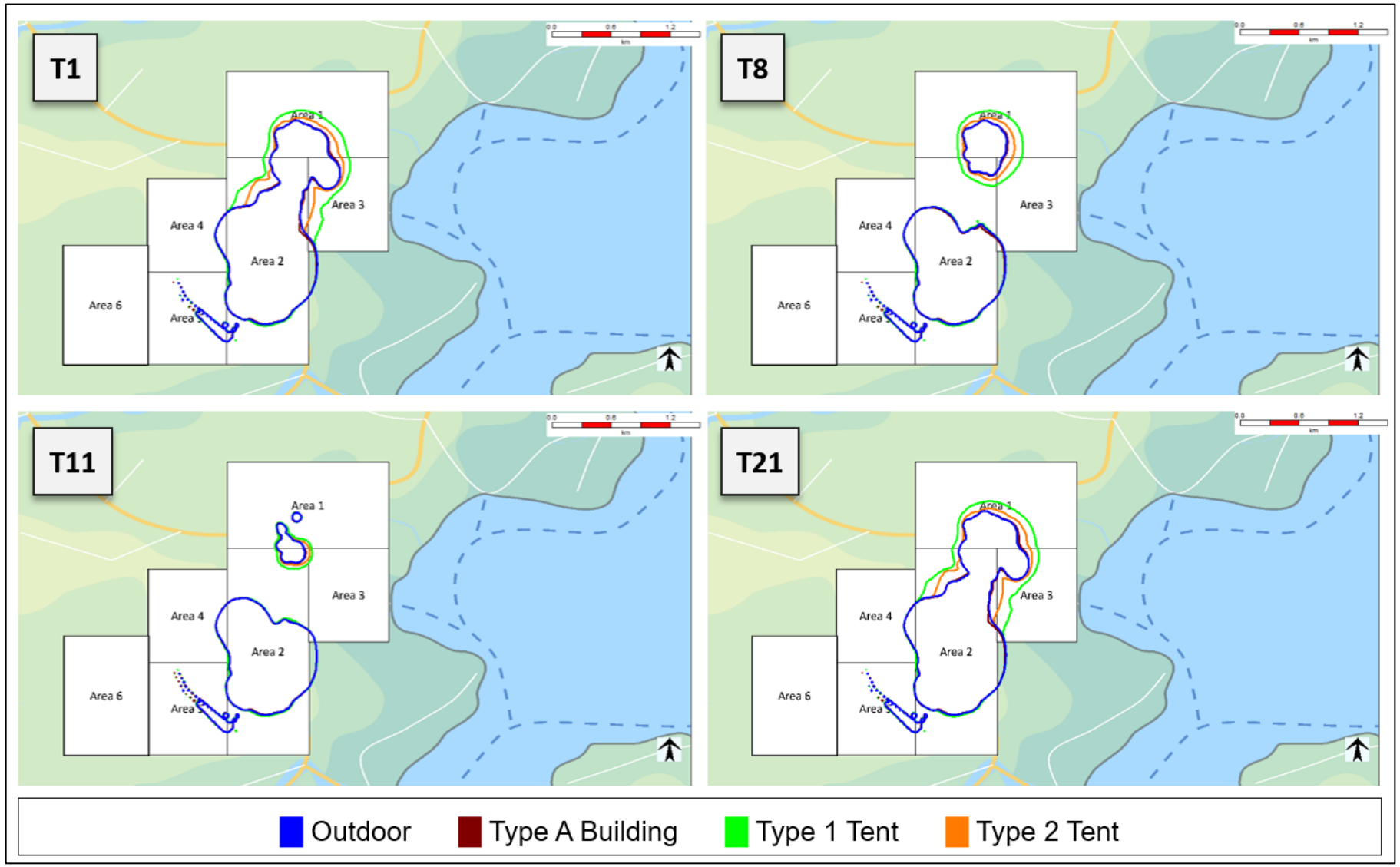


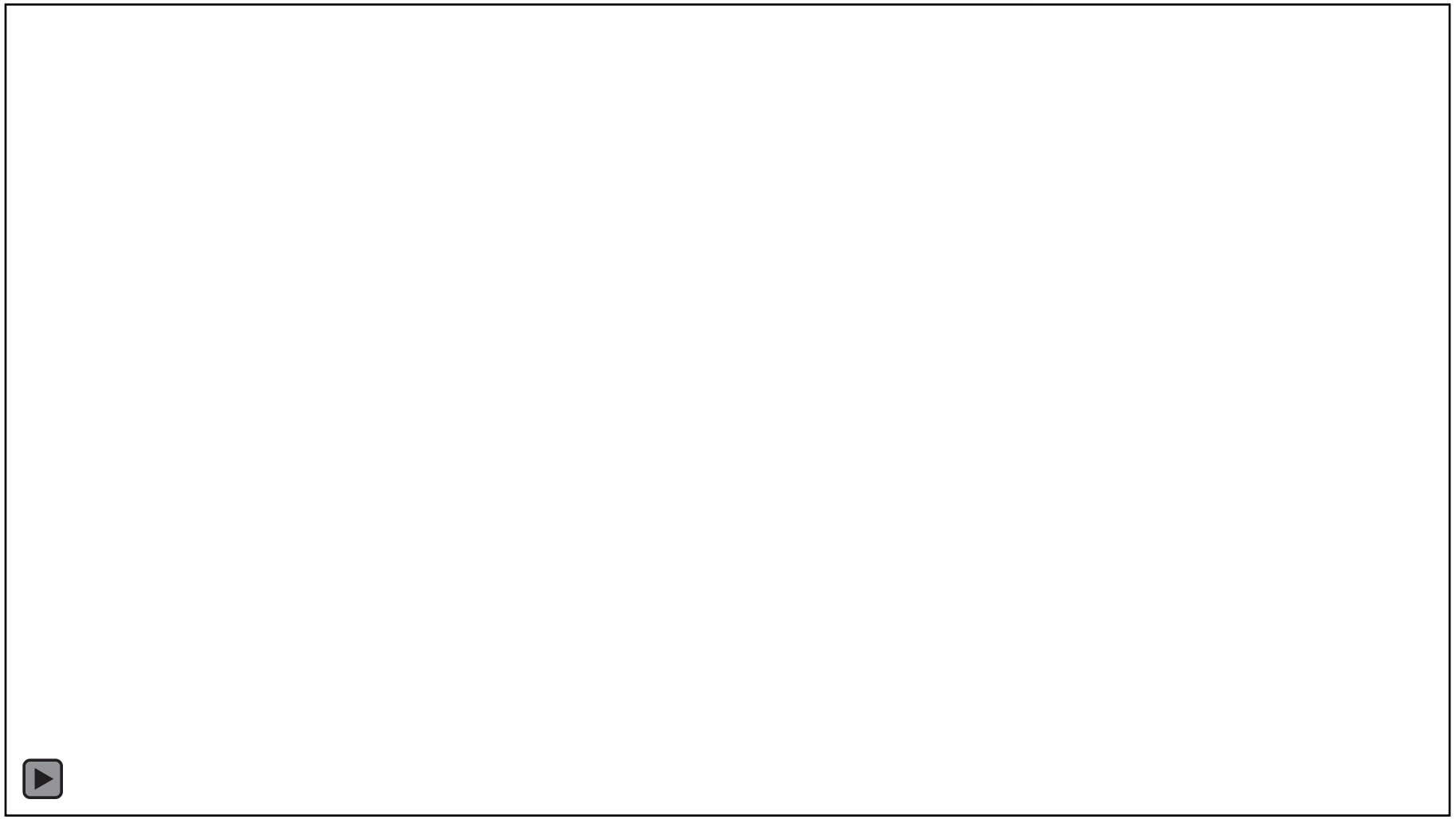
- Temporary contract workers may work at multiple sites throughout the year
- If operators relaxed risk criteria, the result would be a significant increase in the worker's risk exposure
- A prudent decision is not to relax risk criteria during non-routine operations



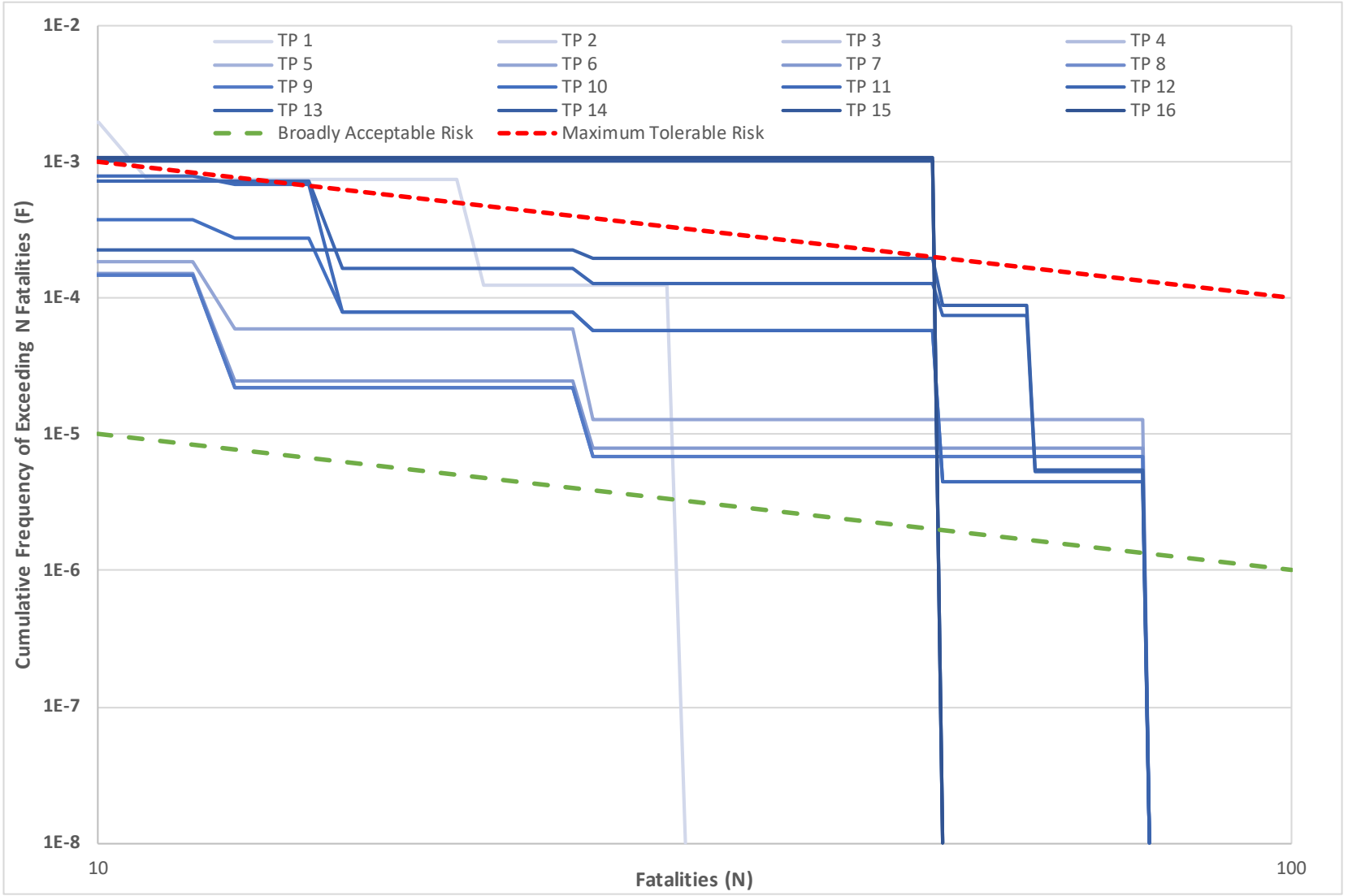
Results are Developed for Each Time Period Combination

Areas	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A	2.9E-5	2.9E-5	2.9E-5	2.8E-5	2.8E-5	6.5E-6	4.3E-6	3.4E-6	3.4E-6	1.0E-6	1.0E-6	1.0E-6	1.0E-6	2.6E-5	2.6E-5	2.9E-5	2.9E-5	2.9E-5	2.9E-5	2.9E-5	2.9E-5	2.9E-5	2.9E-5	2.9E-5
B	6.6E-5	6.6E-5	6.6E-5	6.6E-5	6.6E-5	2.4E-5	4.3E-6	2.6E-6	2.6E-6	6.1E-7	6.1E-7	9.1E-7	9.1E-7	4.7E-5	4.7E-5	6.6E-5	6.6E-5	6.6E-5	6.6E-5	6.6E-5	6.6E-5	6.6E-5	6.6E-5	6.6E-5
C	1.4E-3	1.4E-3	1.4E-3	7.7E-4	7.7E-4	7.7E-4	9.1E-5	9.1E-5	8.9E-5	7.1E-5	7.0E-5	7.0E-5	7.0E-5	7.3E-4	7.3E-4	1.4E-3	1.4E-3	1.4E-3	1.4E-3	1.4E-3	1.4E-3	1.4E-3	1.4E-3	1.4E-3
D	1.1E-4	1.1E-4	1.1E-4	8.1E-5	8.1E-5	7.0E-6	7.0E-6	6.6E-6	6.6E-6	4.6E-8	1.9E-8	1.9E-8	7.4E-5	1.0E-4	1.0E-4	1.0E-4	1.0E-4	1.0E-4	1.1E-4	1.1E-4	1.1E-4	1.1E-4	1.1E-4	1.1E-4
E	2.1E-4	2.1E-4	2.1E-4	1.9E-4	1.9E-4	1.1E-5	1.1E-5	1.1E-5	1.0E-5	1.3E-7	1.3E-8	1.3E-8	1.8E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.1E-4	2.1E-4	2.1E-4	2.1E-4	2.1E-4	2.1E-4
F	1.3E-4	1.3E-4	1.3E-4	1.3E-4	1.3E-4	6.0E-7	6.0E-7	4.6E-7	4.6E-7	4.7E-9	4.7E-9	4.7E-9	1.3E-4	1.3E-4	1.3E-4	1.3E-4	1.3E-4	1.3E-4	1.3E-4	1.3E-4	1.3E-4	1.3E-4	1.3E-4	1.3E-4
I	2.8E-4	2.8E-4	2.8E-4	2.8E-4	2.8E-4	6.6E-5	6.6E-5	6.6E-5	6.6E-5	5.3E-5	5.3E-5	2.0E-4	2.0E-4	2.8E-4	2.8E-4	2.8E-4	2.8E-4	2.8E-4	2.8E-4	2.8E-4	2.8E-4	2.8E-4	2.8E-4	2.8E-4
J	3.4E-4	3.4E-4	3.4E-4	3.4E-4	3.4E-4	4.8E-5	4.8E-5	4.7E-5	4.7E-5	3.5E-5	3.5E-5	2.1E-4	2.1E-4	3.4E-4	3.4E-4	3.4E-4	3.4E-4	3.4E-4	3.4E-4	3.4E-4	3.4E-4	3.4E-4	3.4E-4	3.4E-4
K	4.9E-4	4.9E-4	4.9E-4	4.1E-4	2.6E-4	2.5E-4	6.3E-6	5.8E-6	5.8E-6	2.1E-6	2.1E-6	2.1E-6	2.1E-6	9.4E-5	9.4E-5	3.4E-4	4.9E-4	4.9E-4	4.9E-4	4.9E-4	4.9E-4	4.9E-4	4.9E-4	4.9E-4
L	7.2E-4	7.2E-4	7.2E-4	1.7E-4	4.4E-5	3.9E-5	5.0E-6	4.4E-6	4.4E-6	2.0E-6	2.0E-6	2.0E-6	2.3E-6	5.6E-4	5.6E-4	5.9E-4	7.2E-4	7.2E-4	7.2E-4	7.2E-4	7.2E-4	7.2E-4	7.2E-4	7.2E-4
M	3.6E-4	3.6E-4	3.6E-4	3.6E-4	3.6E-4	3.6E-4	3.5E-4	3.5E-4	2.9E-4	2.3E-4	2.3E-4	2.3E-4	2.3E-4	2.3E-4	2.3E-4	2.5E-4	3.0E-4	3.0E-4	3.6E-4	3.6E-4	3.6E-4	3.6E-4	3.6E-4	3.6E-4
N	3.5E-4	3.5E-4	3.5E-4	3.5E-4	3.5E-4	3.5E-4	3.5E-4	3.5E-4	8.1E-5	2.9E-5	2.9E-5	2.9E-5	2.9E-5	2.9E-5	2.9E-5	3.0E-5	3.0E-4	3.0E-4	3.5E-4	3.5E-4	3.5E-4	3.5E-4	3.5E-4	3.5E-4
O	4.7E-4	4.7E-4	4.7E-4	4.7E-4	4.7E-4	1.5E-4	1.5E-4	1.5E-4	1.0E-4	2.2E-6	2.2E-6	2.2E-6	1.8E-5	1.9E-5	1.9E-5	1.9E-5	6.3E-5	6.3E-5	5.4E-4	5.4E-4	5.4E-4	5.4E-4	5.4E-4	5.4E-4


T1
T8
T11
T21
Area 1
Area 2
Area 3
Area 4
Area 6
Outdoor
Type A Building
Type 1 Tent
Type 2 Tent



https://www.youtube.com/watch?v=9y-0pazEvaE



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SPRING24+20TH GCPS
A Joint AIChE and CCPS Meeting

March 24–28, 2024
New Orleans Ernest N. Morial Convention Center,
New Orleans, LA

Reducing Risks in Abnormal Operations & T/A

Co-locate equipment for S/D in adjacent areas, or time process unit shutdowns and downtimes by area.

Equipment that continues to present risk in the area will limit the ability to locate personnel during T/A, even after units are shutdown.

Reconsider using tanks near process units during T/A.

Consider shifting storage operations to eliminate or limit the use of tanks near work areas to reduce the risk

.

Construct temporary structures, prior to the T/A to minimize risk from S/D operations

Avoid workers assembling/siting buildings during periods of increased risk.

Develop a system to manage and control occupancy once buildings are sited

Access control and signage, as well as periodic reviews.

Evaluate affects on adjacent or interconnected units during non-routine operations.

Operations may be impacted by changes in feed/product routing, reduced staffing levels, capacity changes, or other risk factors.

Dynamic QRA can be performed with Safeti

This can be done by exploiting run rows and combinations features in the software

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Questions?

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