Fire and Gas Mapping-Updates to ISA84 TR7

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Agenda

- Introduction to Fire and Gas (F&G) mapping
- Updates to ISA84 TR7
- Example for fire detector analysis
- Discussion on coverage types
- Case Study discussion
- Summary

Introduction to F&G mapping

- FGS(Fire and Gas system) is a detection and a shutdown system based on fire and gas detectors detecting a fire or a gas/toxic release
- Employed widespread across the process and other industries
- FGS often documented as safeguards for fire/gas/toxic releases
- FGS often intertwined with SIS (esp. in O&G service)

Why should you be interested?

- Your recommendations drive the sites to add more fire and gas detectors. If you know and understand the methods to do mapping, you can provide better and more detailed recommendations for your clients/sites
- Understand the changes that are coming in the fire and gas mapping arena can help you educate your clients/sites better and reduce insurance risks further

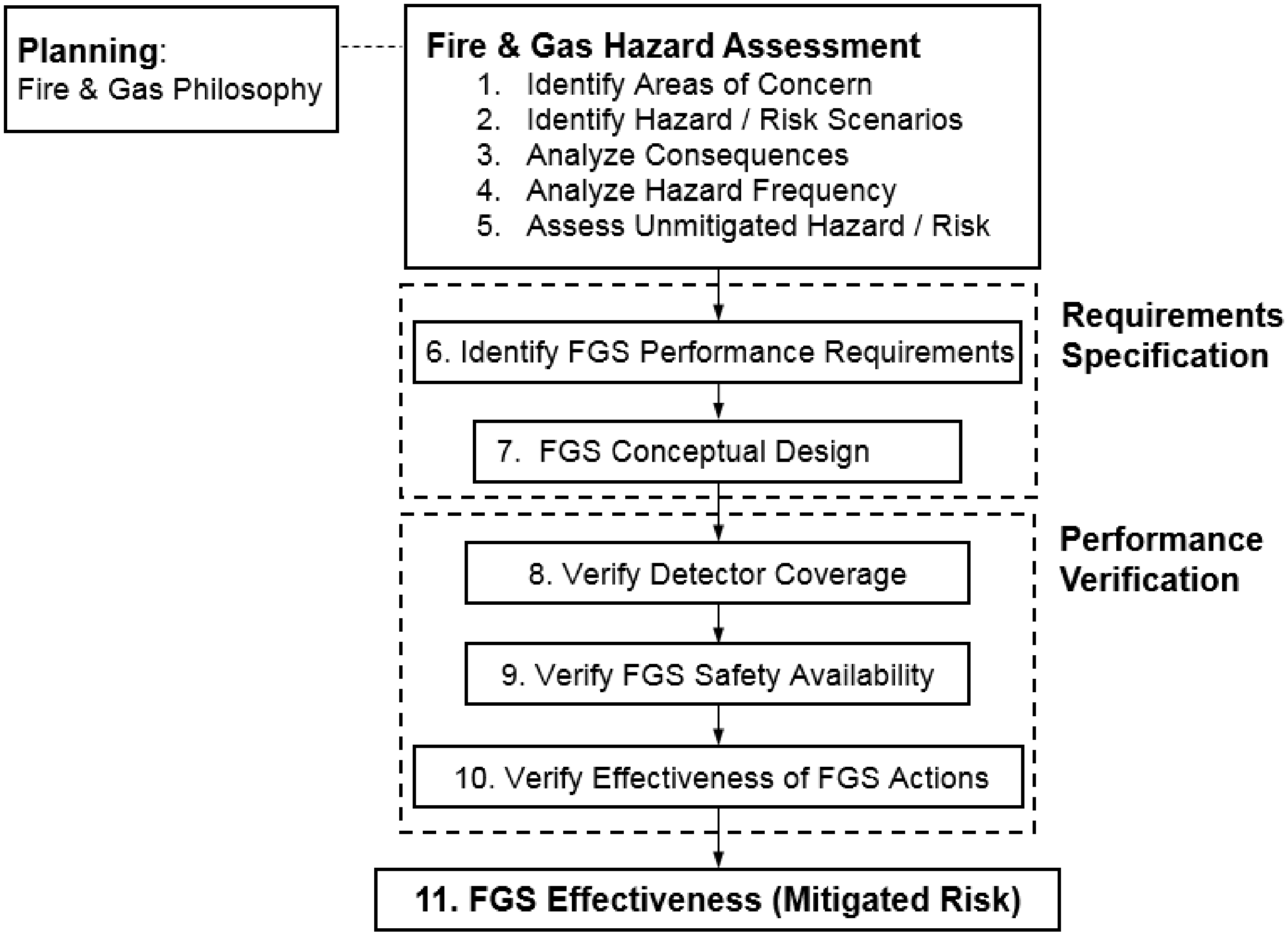
What is TR84.00.07?

- "Guidance on the Evaluation of Fire, Combustible Gas and Toxic Gas System Effectiveness"
  - Also called "**ISA 84 Technical Report 7**"
  - Written by members of ISA 84 committee
  - Released in January 2010, new version about to be released (in ballot right now)
  - Non-normative
- Provides guidance for those implementing a performance-based FGS

General Concepts of TR7

- Establishes a flexible lifecycle approach similar to ISA 84 SIS lifecycle
- Describes performance-based (PB) approaches to FGS design
- Provides multiple example applications
- Doesn’t restrict traditional prescriptive FGS approaches (NFPA 72, EN 54-2….)

FGS Lifecycle



Fire Detection Philosophy

- Goal is to detect fire as early as practical in order to reduce the possibility of escalation, minimize impact the asset, and allow personnel to take appropriate protective actions.
- Successful Mitigation
  - Alarm and Notification
  - Evacuation
  - Isolation of fuel source
  - Depressurize the process
  - Initiate fixed fire suppression
  - Shutdown ventilation

Gas Detection Philosophy

- Goal is to detect credible gas releases by strategically placing detection equipment in proximity to release sources in order to minimize potential for extended duration gas release that could result in severe consequences.
- Successful Mitigation
  - Alarm to evacuate personnel
  - Automatic or operator actuated ESD
  - Isolate fuel source and depressure
  - De-energize electrical sources
  - Shelter-In-Place for toxic releases

Key TR7 Definitions

FGS Effectiveness = FGS *Detector Coverage* x
FGS Availability x
FGS *Mitigation Effectiveness*

- FGS Detector Coverage
  - Geographic coverage/ Scenario coverage
- FGS Availability
  - 1- Probability of Failure on Demand(PFD)
- FGS Mitigation Effectiveness
  - Probability of successful hazard mitigation by FGS

Performance Based

	FGS Detector Coverage	FGS Safety Availability	FGS Mitigation Effectiveness		Relative Likelihood	Outcome
		Yes	0.9		0.76	Mitigated
	Yes	0.99				
	0.85		0.1		0.08	Unmitigated
Design Basis Hazard		No				
1		0.01			0.01	Unmitigated
	No					
	0.15				0.15	Unmitigated
			FGS Effectiveness		0.76	

Performance Based

- Performance targets for FGS Detector Coverage should be quantified for all applications where any risk reduction is claimed
- Wherever FGS target RRF exceeds 10, FGS Safety Availability should be quantified.
- Wherever FGS target RRF exceeds 10, FGS Mitigation Action Effectiveness should be quantified.

Updates to ISA84 TR7

2010 vs 2017 version

Current (2010 version)

- Covers detection
- Development of Safety Life Cycle (SLC)
- Defining F&G functions
- Examples of performance based system

Upcoming (2017 version)

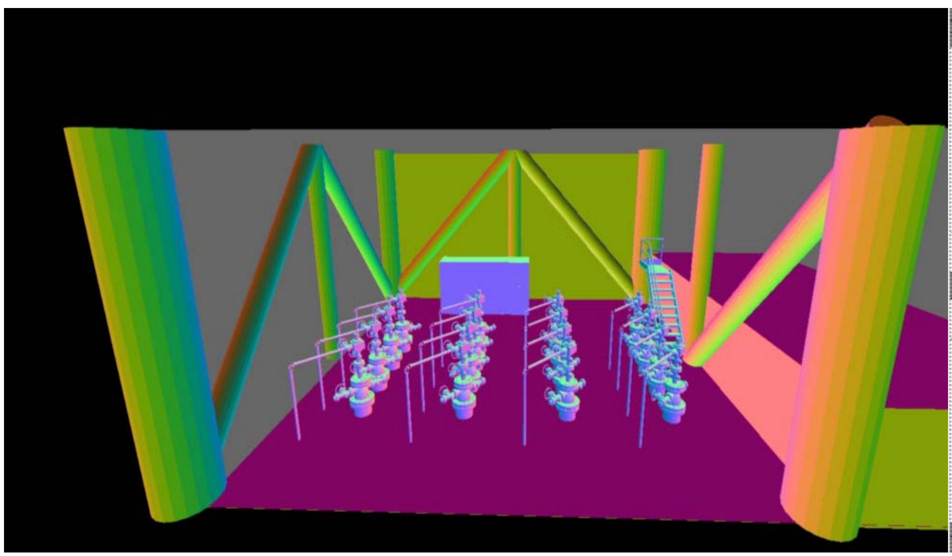
- Covers detection and mitigation
- Design associated with SLC
- Same as 2010
- Same as 2010
- Coverage or effectiveness <10% = RRF<10
- Adds to prescriptive method
- Mitigation effectiveness

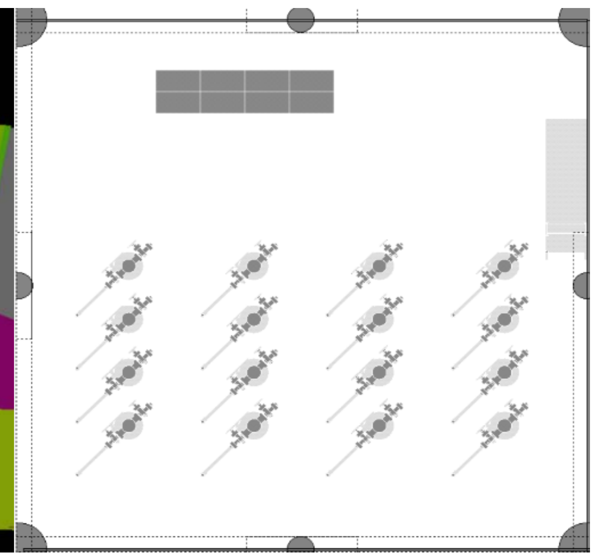
Examples provided in ISA84 TR7

- Annexes in the TR provide examples for fire, flammable gas and toxic detectors
- Current presentation to focus on one example for fire detection in the well bay

Example description

- Offshore oil and gas production platform
- Rectangular area with length of 65ft
- Module contains 16 wellhead assemblies





Analyzing hazard and frequency

- Consequence
  - Leak from wellhead with possible jet fire
  - Wellhead material is at 1500 psig, 100F
  - Possible loss of $10MM
  - Consequence adjusted with pressure (3.5)

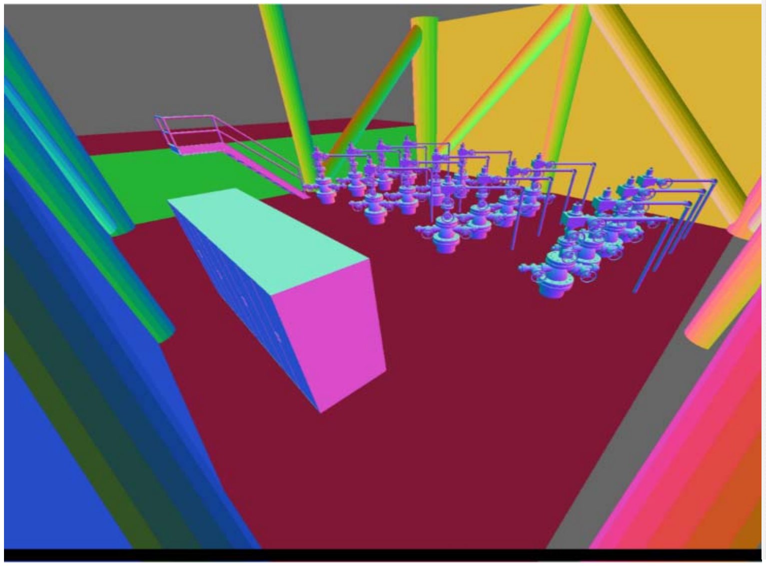
- Likelihood
  - Base likelihood of leakage (2)
  - Adjusted likelihood based on occupancy and probability of ignition (-0.5)

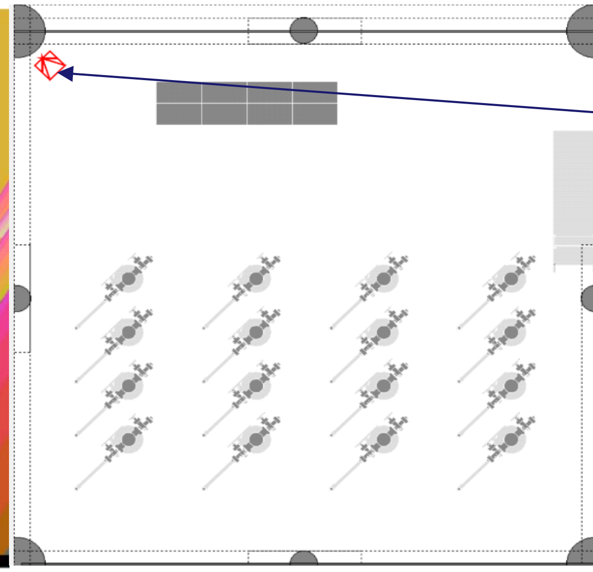
Unmitigated Risk

- Hazard rank
  - Grade B
  - Required fire detection coverage = 80%

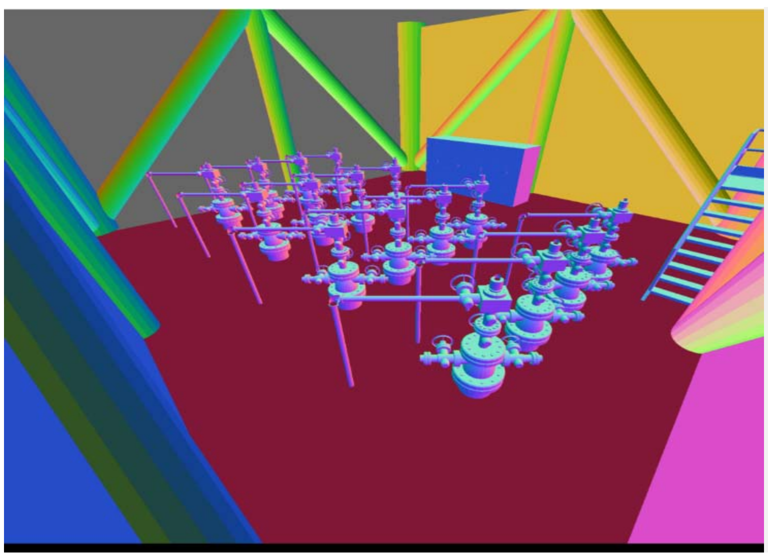
Adjusted Hazard Rank	Grade	Fire Detection Coverage
>=7	A*	> 0.90
5 to <7	A	0.90
2 to <5	B	0.80
0.5 to < 2	C	0.60
<0.5	N/A	No Target Coverage

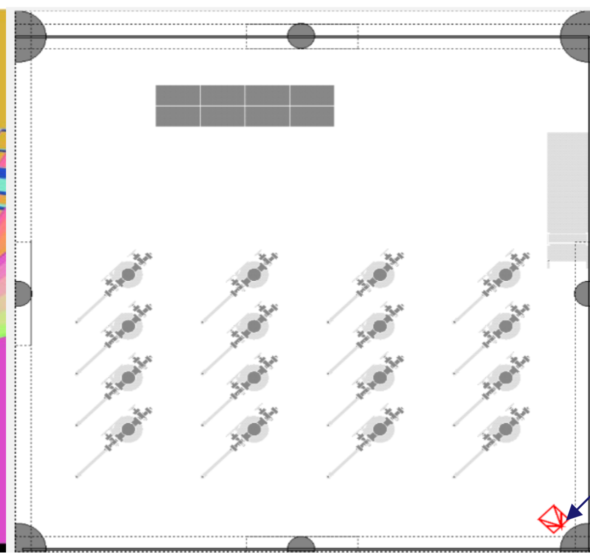
Initial Design





Detector 1

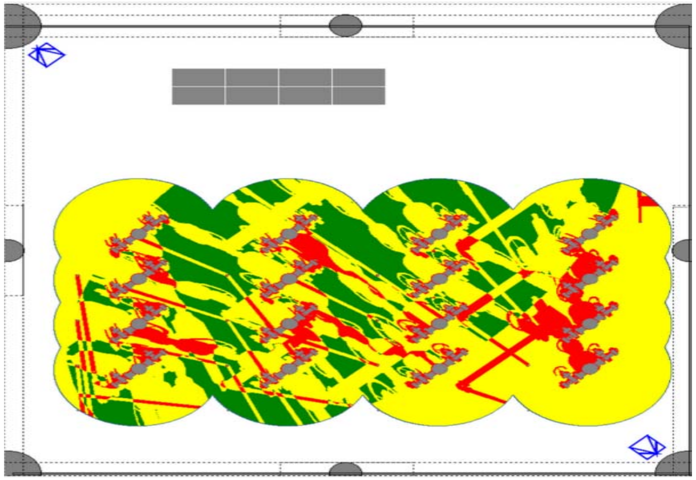




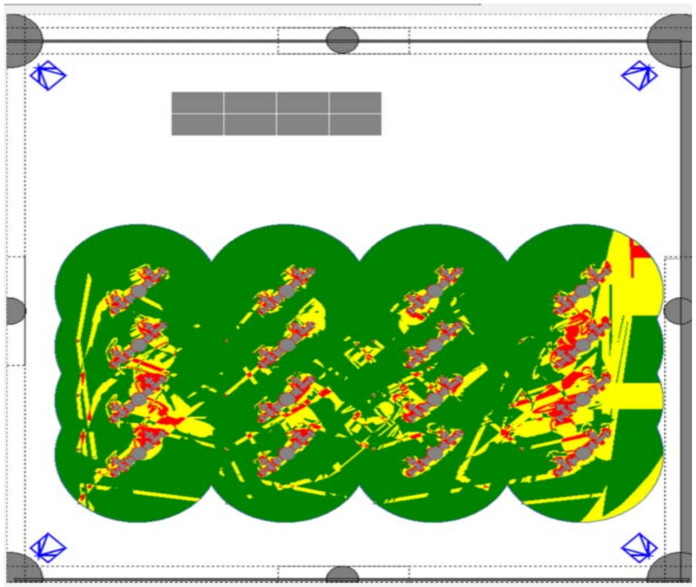
Detector 2

Results

- Detector coverage (atleast 2 detectors detect) is 24%



- With 2 additional detectors, coverage increased to 82%



Mitigation Effectiveness

- Design intent is to detect incipient fire (50 kW) and
  - Initiate wellhead shut-in
    - Verified by calculations of the shutdown action reliability
  - Open deluge valves
    - Firewater analysis performed to verify adequate supply available
    - Adequate deluge coverage provided
  - Start fire water pump
    - Verified by testing periodically

Example – overall summary

- With 4 detectors, coverage for atleast 2 detectors (2ooN) is 82%, which is higher than the target of 80%
- Mitigation is effective and can prevent escalation

Types of Coverage

Definitions (ISA84 TR7)

- Geographic Coverage : The fraction of the geometric area or volume of a defined monitored process area that, if a hazard were to occur in a given geographic location, would be detected considering the defined voting arrangement
  - In other words: % of area covered
- Scenario Coverage : The fraction of the hazard scenarios from process equipment within a defined and monitored process area that can be detected considering the frequency and magnitude of the hazard scenarios and the defined voting arrangement
  - In other words : % of scenarios detected

Pros/Cons of Geographic Coverage

- Advantages
  - Easy to understand graphical representation of results
  - Easily repeatable and auditable detection layout
  - Better for smaller releases
- Disadvantages
  - Doesn’t account for gas migration and ignition
  - Number of detectors required are very high
  - Higher lifecycle cost and possible nuisance alarms/trips

Pros of Scenario Coverage

- Advantages
  - Based on gas cloud and migration
  - Limited detector requirement
  - Can be designed for risk

  - Most favorable for Insurance Risk perspective
    - Reduces nuisance trips
    - Covers area of higher risk with more detectors
    - Quantitative approach allows for calculations in savings through reduced incidents vs lifecycle cost

Challenges with scenario coverage

- Depends on the number of scenarios defined
  - What are the right number of scenarios?
  - How to consider the different elevations?
  - In how many directions you need to rotate the release?
- Depends on the fluctuations in the plume concentration
  - Is there enough time for the sensor to detect?
- Models are mostly steady-state
  - Most models don’t consider transients
  - The transient models available mostly do not explicitly model the depressurization of a complex system
- Models for cross-wind and up-wind are not precise
- Different detectors have different response times
  - Response characteristic impacts if detection is successful
  - Impacts the speed of the response

Case study for Scenario Coverage

- To answer some of the questions, we proposed to perform a series of tests
- Tests were performed with saturated propane for ½”, ¾” and 1” releases in 5 different orientations
  - Horizontal (predominant wind direction)
  - West
  - East
  - Up
  - Down
- 74 tests were performed ranging from 1 to 1.5 minutes
- 14 detectors were placed 60ft upto 200ft from the release point (3 different manufacturers)

Case Study

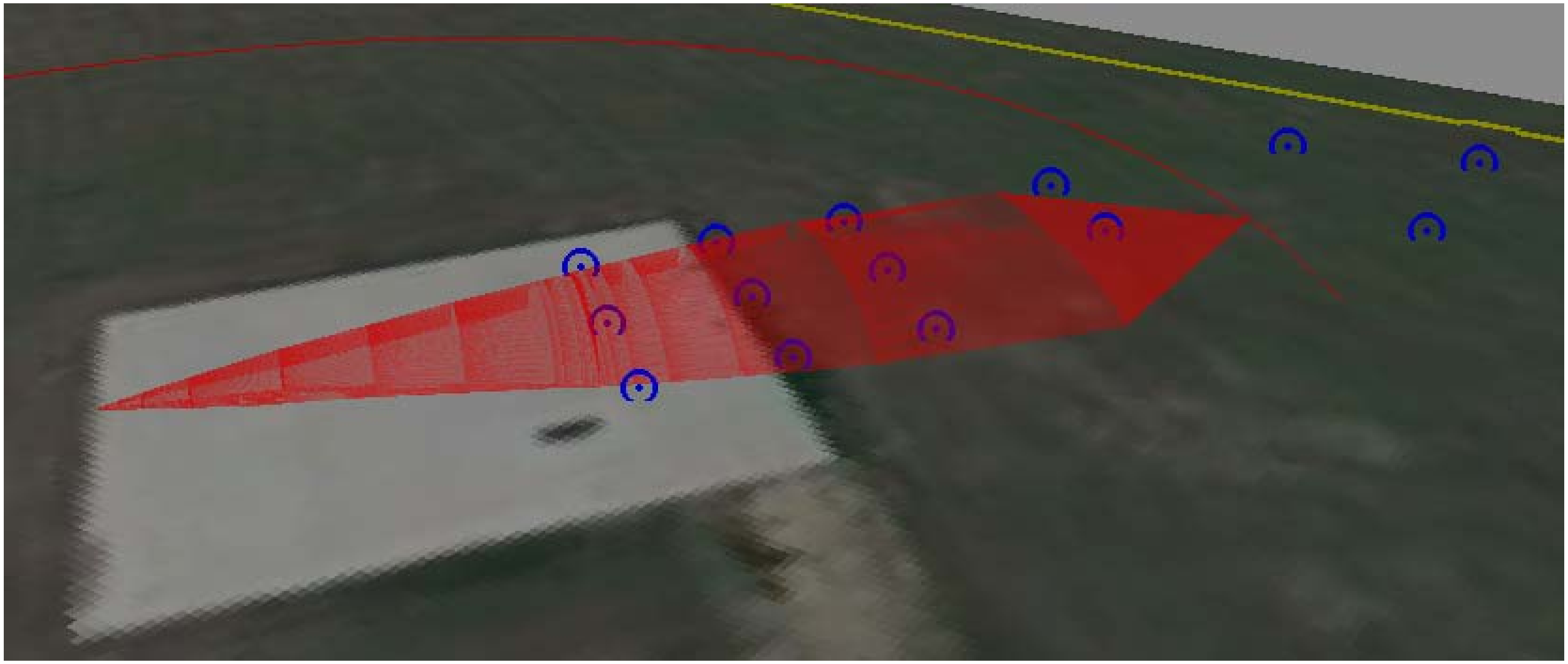
- Initial 5 tests were performed to calibrate the difference in response with and without weather baffles
- Next 5 tests were performed to calibrate detector response from different manufacturer detectors
  - 3 detectors were placed very close to each other in the direction of the release
- Remaining 64 tests were conducted randomly to determine the response for various release sizes, orientation and weather conditions
  - Tests were performed in late morning and afternoon, night and early morning to capture different wind conditions
- Weather data was recorded for the tests

Case study

- For this presentation, only ½” release will be considered.
- A total of 34 tests were conducted for ½” release
  - Downwind tests : 8
  - Vertical (Up): 6
  - Crosswind (west): 5
  - Crosswind (east): 7
  - Vertical (Down) : 8
- Detectors were not moved throughout these tests to ensure proper comparison
- All detectors were located at 1.5ft

Case study results

- Horizontal release downwind



Case study – videos(horizontal – downwind)

Case study - results

- Scenario coverage for 1oo1 detector is 59%
- Scenario coverage for 2oo2 detector is 32%
- Average time to alarm is 55-60s for detectors in the direction of the wind after the release has occurred
- None of the releases in the up or west direction get detected
- Concentrations read by different detectors placed side by side varied significantly
- Wide ranging fluctuations were observed in concentrations during the test duration
- Speed of rise and maximum concentrations varied significantly between detectors

Summary

Recap

- New ISA84 TR7 has significantly improved guidance on fire and gas mapping
  - Emphasis on mitigation effectiveness has increased significantly
  - More details and examples on how to design the fire and gas system
  - Guidance on how to tie the prescriptive approach with performance based approach
  - Provides help on reducing risk quantitatively and hence reduce the costs of gas release or a fire

Recap

- Have a discussion with your sites about which approach to use:
  - Prescriptive
  - Geographic Coverage
  - Scenario Coverage
- All the approaches have their pros and cons, understand them and take the best approach to achieve optimal risk reduction
- A hybrid approach with all of the three methods might be the best way to move forward
- Placing the detectors correctly saves you the most $$

Questions?

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