2023 ENGINEERING INSTITUTION OF ZAMBIA SYMPOSIUM

P23 - A Transient and Computer-based Style for Numerical Menace Evaluation of the Domino Mishap

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DATE : Friday 21st April 2024

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Presentation Outline:

1. Introduction
2. Literature Review
3. Methodology
4. Results and Analysis
5. Conclusions & Recommendations

Introduction:

- Many flammable petroleum products are stored in oil depots, such as oil terminals or gas stations (Zhou Y. et al., 2016).
- The incidents generated by the domino effect are the ones that have the most disastrous outcomes(Mesa-Gómez et al., 2020).

Figure 1. The Domino Effect

Introduction Continued:

Problem Identification

- Escalation triggered by fires resulting in domino scenarios was the cause of severe accidents in the industry. The escalation vector involved in fire accidents in petroleum plants is heat radiation. In order to evaluate the impact of heat radiation during a fire accident, risk analysis is performed.

Main Objectives

- To perform a risk analysis on the escalation effect during a fire accident that cause domino effect.
- Evaluate the impact of heat radiation to the surrounding during a fire accident based on escalation using GRaphical Interface for reliability Forecasting (GRIF) software.

Literature Review:

SN.	Authors	Technique Used	Research Gap
1	(Baybutt , 2015)	Hazard and Operability (HAZOP) analysis	Subjective and dependent on the quality of the team
2	(El-Awady, 2023)	Failure Mode Effect Analysis (FMEA)	Issues beyond team members' knowledge aren't likely to be detected or resolved
3	(Lyon & Popov, 2018)	What-if analysis (examples of qualitative methodologies)	This technique can be incomplete and miss some hazard potentials.
4	(Deyab, n.d.).	Event tree (ET), Fault Tree (FT), and Bow-Tie Analysis (BT) (quantitative ones)	There is not enough data to be analyzed
5	(Rathnasekara & Gunasek-era, 2024),	Human factors analysis and classification system for the oil and gas industry (HFACS-OGI)	Limited Scope

Methodology:

Desk study

- Research on literature review.

Experimental investigation

- Study the facilities and equipments in a petroleum plant and modelling the plant in GRaphical Interface for reliability Forecasting (GRIF)
- Identifying the potential facility or equipment that have the potential to be a primary event for a fire.
- Run the simulation to evaluate the impact of heat radiation from the primary scene of the fire to the surrounding facilities and equipment.

Interpretation and conclusion

- Evaluation of the potential impact of the fire domino accident in a petroleum plant.
- Evaluation of the potential value loss of properties due to fire domino accident in a petroleum plant.

Figure 2. Methodology Flow Chart

Methodology Continued:

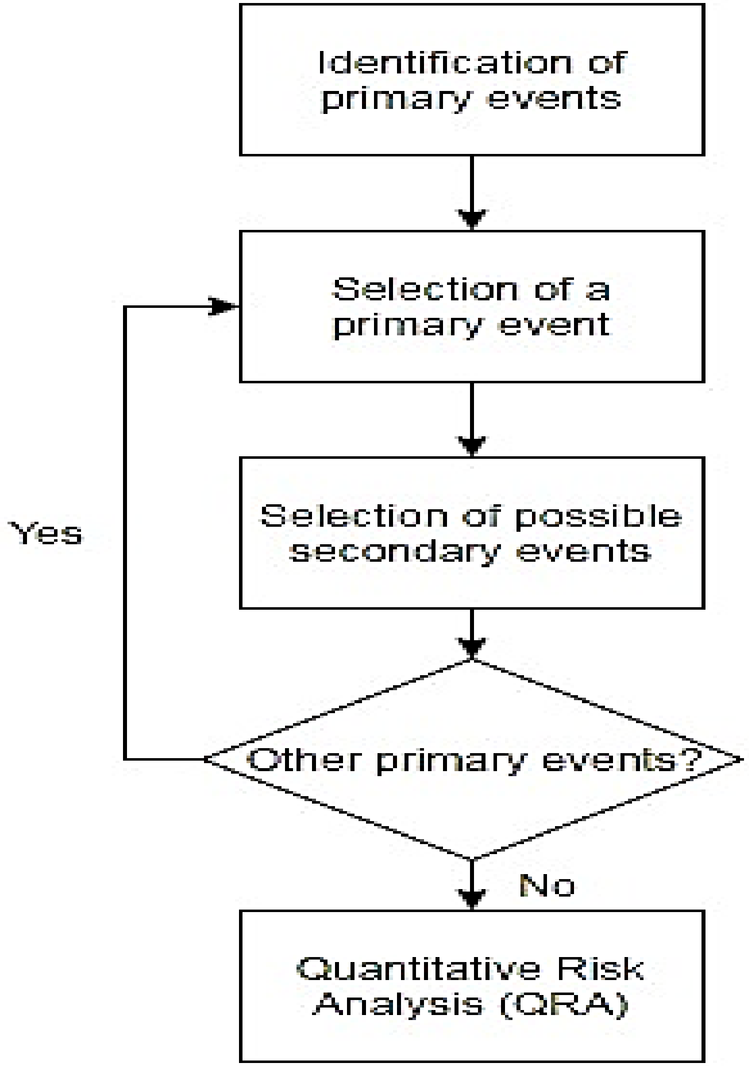

Figure 3. Flow Chart of Domino Accident Methodology

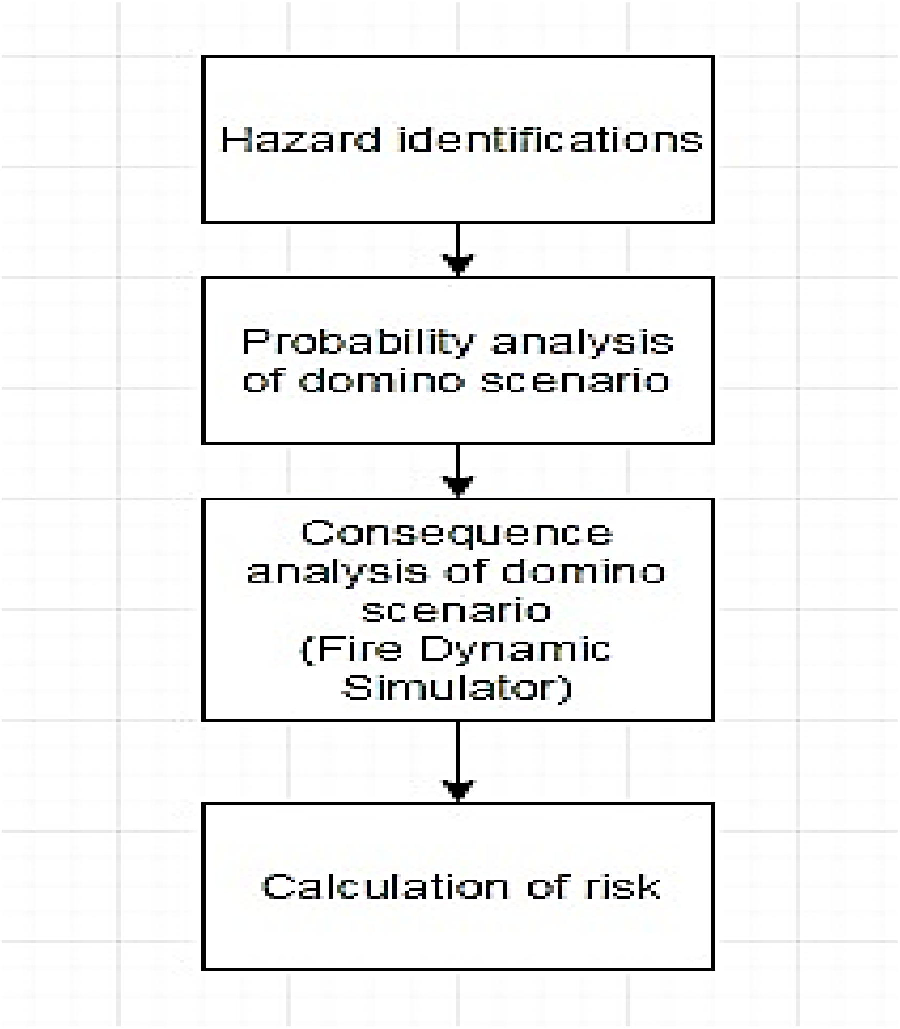

Figure 4. Flow Chart of Quantitative Risk Analysis (QRA)

Results and Analysis:

Use case:tanks were cylindrical with a capacity of ten metric tons of gasoline.

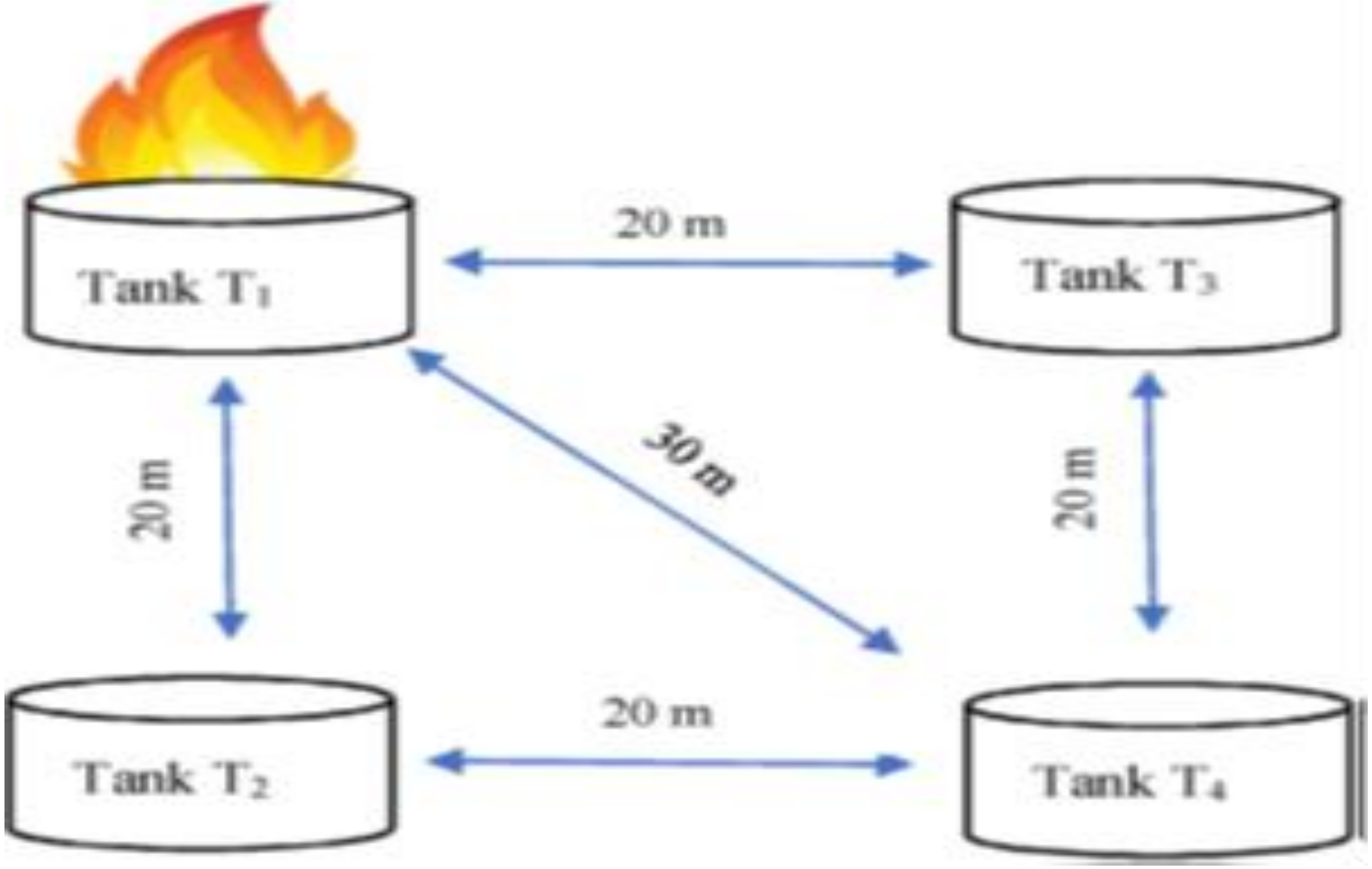

Figure 5. The Use Case

Analysis continued:

Generalised Stochastic Petri-Net Model

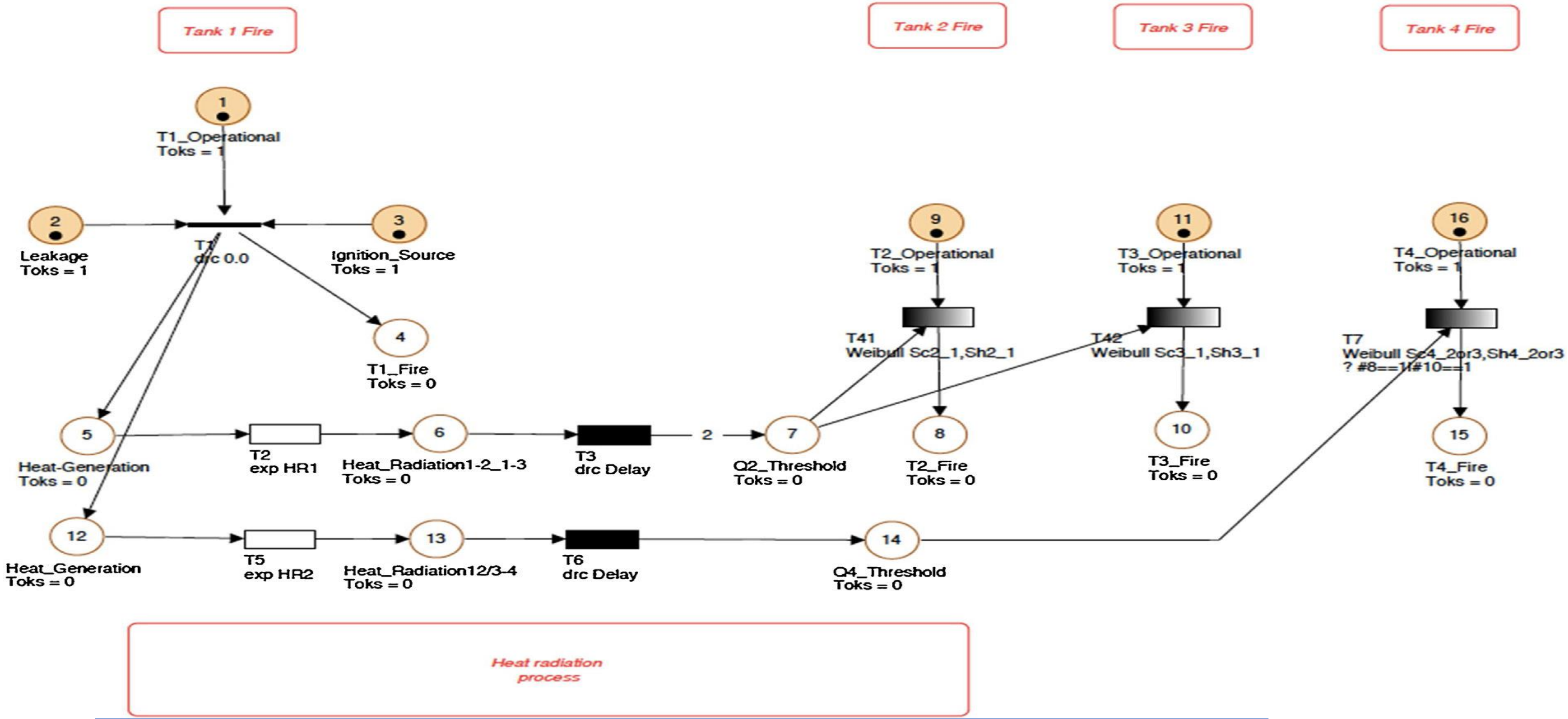

Figure 6. The GSPN Use Case Model

Results and Analysis continued:

Name	σ (Average)
Tank1_Operational : 1	0
Leakage: 2	0
Ignition_Source : 3	0
Tank1_Fire : 4	0
Heat_Generation : 5	0.079466567
Heat_Radiation1-2_1-3 : 6	5.12735E-18
Q2_Threshold : 7	0.033631666
Tank2_Fire : 8	0.460042475
Tank2_Operational : 9	0.460042475
Tank3_Fire : 10	0.45104425
Tank3_Operational : 11	0.45104425
Heat_Generation12/3-4 : 12	0.074827471
Heat_Radiation12/3-4 : 13	6.96572E-18
Q4_Threshold : 14	0.120061932
Tank4_Fire: 15	0.136768345
Tank4_Operational: 16	0.136768345

Results and Analysis continued:

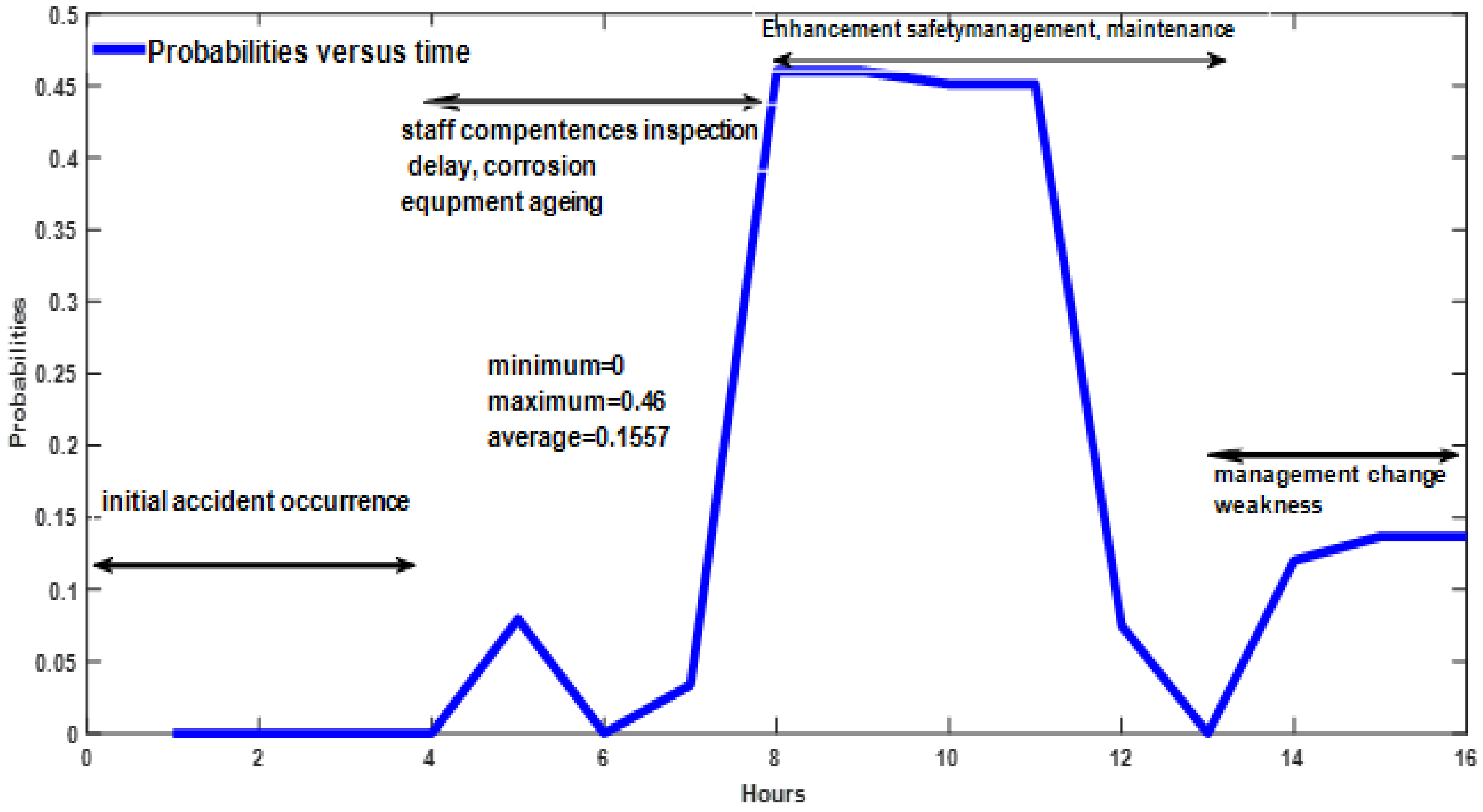

Figure 7. Dynamic Behavior of Risk Based on Our Model

Results and Analysis continued:Validation

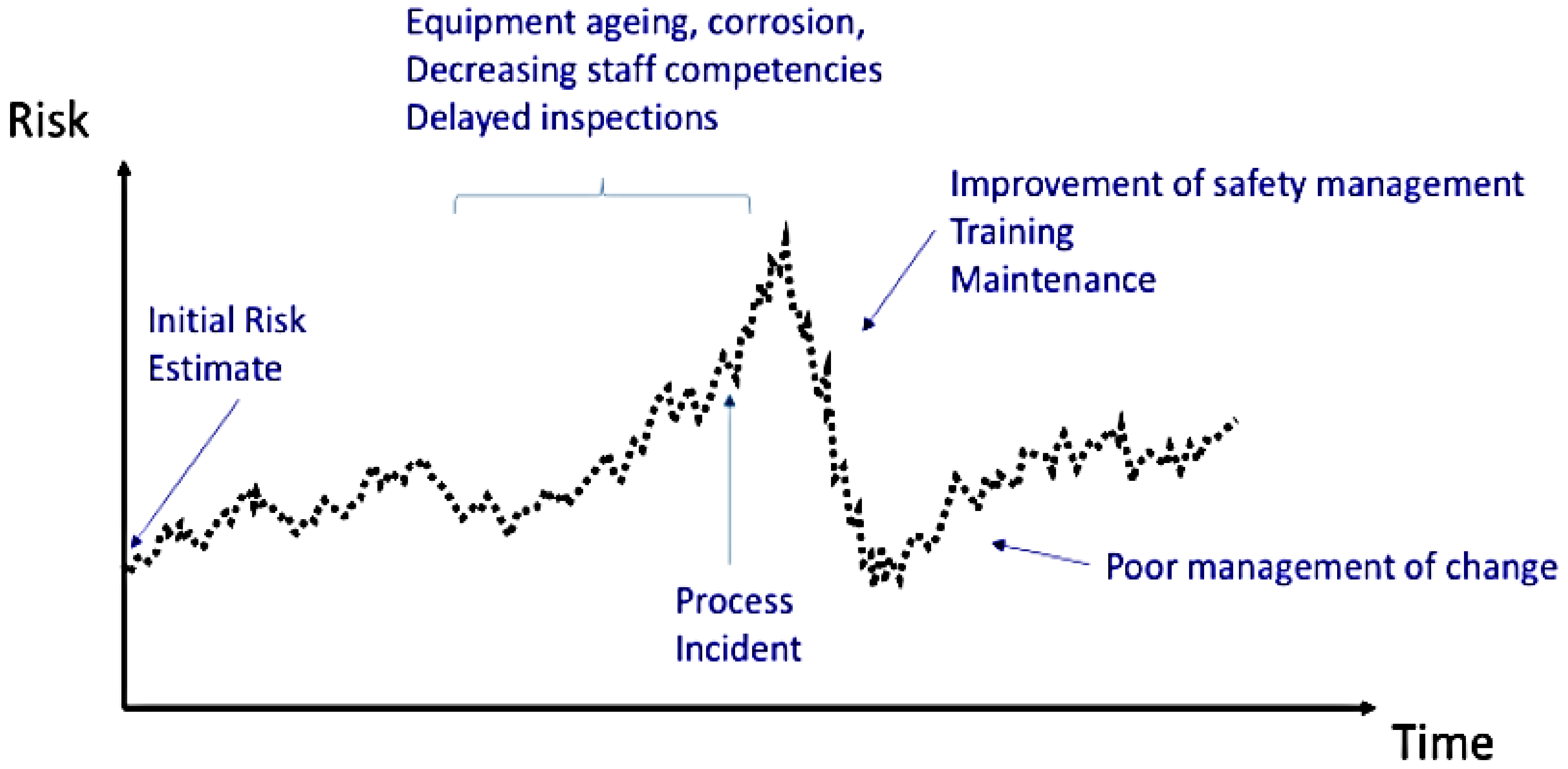

Figure 7. Dynamic Behavior of Risk Based on the Bayesian Model(Kanes et al., 2017)

Conclusion and Recommendation:

- Our model offers better results than the Bayesian model (Kanes et al., 2017) in the following ways:
- The initial accident occurrence at a time interval of 0-4 seconds is zero in our analysis while in (Kanes et al., 2017) it is above two,
- The staff competencies on inspections on the accidents are faster in our analysis, and the initial accident occurrence estimate at time interval is high and there is
- Better management change in scenarios of an accident in our method.

Conclusion and Recommendation:

- This innovative approach is capable of analyzing the failure likelihood as time-dependent, unlike prior techniques used to mimic the domino effect.
- Continuous time-dependent outcomes help to monitor risk, especially in complex systems where domino effect mishaps are typical. Discrete values can only provide an evaluation of the system at a certain point in time
- As a recommendation, analysis and studies on domino effect and escalation effect should be continued so that the risk of having domino accidents in the industry can be minimized and avoiding the bad impact of the accidents.

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