TEHRAN UNIVERSITY OF MEDICAL SCIENCES

IJOH INTERNATIONAL JOURNAL OF OCCUPATIONAL HYGIENE
Copyright © 2022 by Iranian Occupational Health Association (IOHA)
eISSN: 2008-5435

IRANIAN OCCUPATIONAL HEALTH ASSOCIATION IOHA

PERSPECTIVE ARTICLE

Revisiting Tripod Beta: A Perspective on Proactive Incident in High-Risk Workplaces

MAHDI JAFARI NODOUSHAN*

Department of Occupational Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

Received 2025-04-22; Revised 2025-05-18; Accepted 2025-06-02

This paper is available on-line at *http://ijoh.tums.ac.ir*

ABSTRACT

Tripod Beta is a structured methodology developed in response to major industrial accidents, particularly the Piper Alpha disaster. Rather than focusing on human error as the primary cause, Tripod Beta examines the systemic failures that contribute to unsafe acts, namely the underlying latent conditions and failed barriers within an organization. This perspective article reflects on the relevance and application of Tripod Beta in today's high-risk and complex industrial settings. We discuss its theoretical foundations in human factors and systems thinking, review its strengths in promoting organizational learning, and critically assess its current limitations, such as challenges in scalability, digital integration, and applicability across emerging sectors. Furthermore, we outline future opportunities for enhancing the method through digital tools, hybrid models, and expanded training accessibility. By repositioning Tripod Beta as a proactive safety strategy rather than a reactive investigation tool, we argue for its modernization and continued use as a valuable framework in preventing accidents and managing risk in evolving operational landscapes.

KEYWORDS: *Tripod Beta, Accidents, safety barriers, Latent conditions, Human error, High-risk industries*

INTRODUCTION

Accident investigation is a cornerstone of occupational and process safety, particularly in high-risk industries such as oil and gas, aviation, chemical manufacturing, and nuclear power [1, 2]. Understanding how and why incidents occur is essential not only for preventing recurrence but also for improving the robustness of safety management systems. However, traditional approaches to investigation have historically emphasized proximate causes, especially human error. This reductionist view often leads to superficial conclusions and the implementation of short-term fixes that fail to address the deeper systemic contributors to failure [3].

In the early 1990s, in the aftermath of the catastrophic Piper Alpha offshore oil platform disaster, the need for a more systemic and structured approach to accident investigation became apparent. In response, Shell International developed Tripod Beta, a method designed to go beyond human error and examine the organizational and technical weaknesses—referred to as *latent conditions*—that allow accidents to occur. These latent conditions, often embedded in work systems, policies, or organizational culture, interact with immediate causes and failed preventive barriers to create conditions for failure [4-6].

Tripod Beta is grounded in systems thinking and human factors theory, particularly drawing on James Reason's Swiss Cheese Model of accident causation.

Corresponding author: *Mahdi Jafari Nodoushan*
E-mail: *mjn495@gmail.com*

It introduces a barrier-based logic, aiming to identify where barriers (technical, organizational, or human) have failed and why. By using a standardized visual format known as the "Tripod Tree," investigators can map incidents from surface-level events to underlying causes, creating a traceable and holistic representation of how the event unfolded. This has proven particularly useful in complex environments where multiple systems and layers of defense interact [6-8].

Despite its theoretical strength and adoption in several industries, the use of Tripod Beta has not kept pace with technological innovation nor the growing complexity of modern industrial systems. Today's safety challenges involve cyber-physical systems, automation, and new forms of organizational complexity that require updated methods of analysis. Moreover, there is a growing recognition of the need to shift from reactive investigation to proactive risk identification and mitigation.

In this paper, we take a critical look at the current state of Tripod Beta, evaluating its continued relevance and limitations. We also propose opportunities for evolving the method to better align with digital tools, hybrid investigation models, and the needs of emerging industries. Through this lens, we aim to reposition Tripod Beta not just as an investigative technique, but as a forward-looking framework for organizational learning and resilience.

THEORETICAL FOUNDATION OF TRIPOD BETA

Tripod Beta was developed by Shell in the early 1990s, inspired by the work of Professor James Reason. It is built around three core concepts:

1. Latent Failures: Organizational or system-level weaknesses that remain dormant until triggered.
2. Immediate Causes: Unsafe acts or conditions directly involved in the incident.
3. Failed Barriers: Protective systems or controls that failed to prevent the incident.

The method uses "Tripod trees" to model incidents, tracing paths from the incident back through failed barriers and latent conditions, ultimately revealing systemic flaws in design, training, communication, or leadership [6].

CURRENT APPLICATIONS AND STRENGTHS

Tripod Beta has found adoption across several high-risk sectors. Its structured methodology:

- Encourages systemic thinking over blame culture.
- Enables multidisciplinary investigation teams to identify organizational vulnerabilities.
- Produces reports that are actionable and useful for long-term safety improvements.

It has been praised for its ability to capture complexity and facilitate learning from incidents, particularly in cases involving human-machine interactions and layered safety barriers [9].

CHALLENGES AND CRITIQUE

Despite its advantages, Tripod Beta faces several challenges in today's dynamic safety environment:

- Resource Intensive: It demands trained facilitators and time-consuming analysis, limiting its use in smaller organizations.
- Static Modeling: Tripod trees are static and may not adequately reflect the dynamic interactions within complex socio-technical systems.
- Limited Integration: The method remains largely isolated from real-time risk monitoring tools and digital safety platforms.
- Underutilized in Developing Countries: It is due to its methodological complexity and training requirements.

These limitations raise the question: How can Tripod Beta evolve to stay relevant in the age of data-driven safety management [10]?

OPPORTUNITIES FOR EVOLUTION

To enhance the effectiveness of Tripod Beta, we propose several future directions:

1. Digital Integration: Embedding Tripod logic into safety software tools and dashboards can streamline investigation and visualization.
2. Hybrid Models: Combining Tripod Beta with bow-tie analysis, STAMP (System-Theoretic Accident Model and Processes), or AcciMap for broader systemic insight.
3. Training Simplification: Developing modular online training to reduce the learning curve.
4. Cross-sector Adaptation: Adapting Tripod Beta to emerging domains such as healthcare, robotics, and cybersecurity.
5. Data Analytics: Using machine learning to analyze trends across Tripod investigations and predict future barrier failures

DISCUSSION AND TAKE-HOME MESSAGE

Tripod Beta remains one of the most intellectually robust and systemically grounded incident investigation tools available. However, without modernization and digital synergy, it risks obsolescence in a fast-changing industrial landscape. We believe that a revitalized Tripod Beta—one that is more agile, digitally enhanced, and cross-sectoral—could significantly advance proactive safety management and learning from failure. Ultimately, it is not the method alone but the mindset it promotes—a systems-thinking approach to human error and risk—that holds the key to safer organizations.

REFERENCES

1. Ranasinghe U, Jefferies M, Davis P, Pillay M. Resilience engineering indicators and safety management: a systematic review. *Saf Health Work*. 2020;11(2):127–35.
2. Mohamadfam I, Soleimani E, Ghasemi F, Zamanparvar A. Comparison of management oversight and risk tree and tripod-beta in excavation accident analysis. *Jundishapur J Health Sci*. 2015;7(1):e23554.
3. Almeida IMd. The path of accident analysis: the traditional paradigm and extending the origins of the expansion of analysis. *Interface (Botucatu)*. 2006;10:185–202.
4. Fam IM, Kianfar A, Faridan M. Application of tripod-beta approach and map-overlaying technique to analyze occupational fatal accidents in a chemical industry in Iran. *Int J Occup Hyg*. 2010;2(1):30–6.
5. Mashroofeh A, Bolboli MA, Pourbandori A, Shorofeh H, Karimi S. Analysis of root cause of the fatal occupational accidents in a gas refinery using the tripod-beta method. *Occup Med (Lond)*. 2022.
6. Ahmadi O, Mortazavi SB, Asilian Mahabadi H. Application and modification of the Tripod Beta method for analyzing the causes of oil and gas industry accidents. *Int J Occup Saf Ergon*. 2021;27(3):928–37.
7. Shafiei P, Jabbari M, Tehrani MME. Investigation of root cause of work-related accidents in a vehicle manufacturing company using Tripod-Beta method. *J Health Saf Work*. 2021;11(2).
8. Alizadeh Anbardan S. Analysis of the amputation-leading accidents during a mechanical excavator repair using the tripod beta and SCAT combined method in a dam construction project. *J Occup Hyg Eng*. 2019;6(3):9–19.
9. Akhavan A, Reyhani SS, Halvani G. Analysis of fractures and disability defects accidents in Lian Oil Company by Tripod Beta technique. *Occup Med (Lond)*. 2021.
10. Ghahramani A, Zavvar H, Hemmatjo R. Modeling the causes of fuel oil tank fire in an industrial plant using Tripod Beta method. *J Saf Promot Inj Prev*. 2021;9(1):44–54.