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Performance Analysis Technique: An Approach for Understanding the Differences Between Work-as-Imagined and Work-as-Done

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ABSTRACT

Standard operating procedures (SOPs) are widely recognized as essential in maintaining safe operations in high-risk industries, such as oil and gas and petrochemicals. However, limited research has been conducted on the discrepancies between the intended work process (Work as Imagined or WAI) and the actual work process (Work as Done or WAD) under normal working conditions, particularly in these industries. While employees may not always strictly adhere to procedure steps when executing tasks, designing SOPs that allow for adaptation to changing conditions while maintaining adherence remains a challenge. To address this gap, a new approach is proposed in this study that combines two concepts: Hierarchical Task Analysis (HTA) and Abstraction Hierarchy (AH) from work domain analysis. HTA breaks down tasks into a hierarchy of subtasks, while AH decomposes the procedural system into four levels with means-ends relationships. The combination forms the Performance Analysis Technique (PAT). The PAT approach is demonstrated using an SOP for a column flushing task that is part of a three-phase separation system. The results showed that the PAT could visually demonstrate where and how workers make deviations and adaptations to complete a task. This new approach has the potential to improve the design and implementation of SOPs in high-risk industries, enhancing safety and operational efficiency in these environments. The study also highlights the importance of collaboration between procedure writers and frontline workers to design more flexible procedures that recognize adaptation risks.

1 | Introduction

Procedures are indispensable for maintaining safety and efficiency in high-hazard industries including oil, gas, and petrochemicals (Center for Chemical Process Safety 2007). Procedures typically provide detailed, step-by-step instructions for workers carrying out both routine and nonroutine tasks and are often mandated in high-hazard organizations for training and operations (Peres et al. 2016; UK Health and Safety Executive 2020). However, procedures are not always up to date or accurate (Sasangohar et al. 2018). Rigid adherence can sometimes preclude task completion, particularly in dynamic environments involving uncertainties, competing priorities, or varying worker competencies (Dekker 2003; Hale and Borys 2013). As a result, procedural systems often fail to account for real-world complexities and the adaptations needed when procedures fit poorly or do not apply to the given contexts (Carim et al. 2016; Meshkati and Khashe 2015). A better understanding of typical procedural adaptations and deviations under situational constraints is needed to inform the development of more flexible and resilient procedures suited for complex work environments.

Adaptations often require deviations from procedures, and such deviations may be viewed negatively as noncompliance. Indeed, past investigations into incidents consistently underscore the significant role of such procedure noncompliance as a contributing factor. This issue is particularly evident in major incidents such as the Deepwater Horizon and Texas City accidents (US Chemical Safety and Hazard Investigation Board 2007, 2010), as well as numerous near misses across various industries (Alper and Karsh 2009; Bullemer et al. 2011). Traditional retrospective analyses focus on scenarios that yield unexpected or abnormal outcomes (Carvalho et al. 2012; Dekker 2005). However, this emphasis on known failures often overlooks the successful adaptations and effective practices employed during normal operations. To gain a more comprehensive understanding, it is crucial to explore the challenges workers encounter not only during emergencies, but also the trade-offs made during the normal operations to balance competing demands (Hollnagel 2012). This deeper insight can inform procedure design, training methods, and safety management practices.

Hollnagel's (2012) Work-as-Imagined (WAI) versus Work-as-Done (WAD) paradigm addresses the gap between prescribed procedures and actual practice. WAI represents the idealized sequence of steps for a process or task, as delineated in procedures. Conversely, WAD represents the actual methods or sequence of steps used by frontline workers. While deviations from WAI have typically been viewed as violations, research has revealed instances of positive deviations where departures from the formal procedure enhanced productivity without introducing additional operational risk (Marsh et al. 2004; Patterson 2018). Although the disparities between WAI and WAD have been examined across various industries (Ashour et al. 2021; Carvalho et al. 2018; Teperi et al. 2015, 2017), limited research has explored these relationships within the petrochemical sector (Sasangohar et al. 2018; Son et al. 2020). Sasangohar et al. (2018) identified key factors contributing to WAI/WAD differences when workers deviated from procedures. Building on this work, Hendricks and Peres (2021) noted that monitoring the WAI–WAD gap is vital to ensure procedures support safe work, but the methods for doing so are not well established.

One approach to analyzing WAI and WAD is Hierarchical Task Analysis (HTA), a conventional method for task analysis structured around goals and subgoals organized hierarchically and sequentially (Stanton 2006). At the highest level, there's an end goal, while subgoals specify the necessary steps to achieve it (Salmon et al. 2010). This method is both normative (understanding the best way to do something) and descriptive (understanding what is happening) (Havinga et al. 2018), making it event-dependent and suitable for specifying goal-realization processes. HTA has proven useful in healthcare research to conduct in-depth examinations of clinical work processes (Lang et al. 2020; Spurgeon et al. 2019), emergency preparedness (Razak et al. 2019), technology integration in clinical training (Iflaifel et al. 2022), pharmacy medicine dispensing (Ashour et al. 2021), medication administration protocols (Patel et al. 2021), critical incident response (Lang et al. 2020), and handover communication processes (Spurgeon et al. 2019). HTA-based studies have systematically analyzed the layers of tasks and subtasks involved in clinical workflows. The granular, hierarchical decomposition of work processes enabled by HTA revealed meaningful differences and variations between WAI and WAD, highlighting where adaptations, workarounds, and deviations from idealized practices (WAI) occurred in actual (WAD) clinical environments (Iflaifel et al. 2022; Patel et al. 2021; Razak et al. 2019). HTA-based examinations of clinical work systems can inform process enhancements to optimize efficiency, safety, and quality of patient care by bridging the gap between WAI and WAD (Razak et al. 2019; Spurgeon et al. 2019). However, HTA may not fully account for unanticipated events, which may be crucial to system safety (Salmon et al. 2010; Stanton 2006). Thus, HTA provides an adequate yet not all-encompassing framework for aligning WAI and WAD.

In contrast to HTA, Abstraction Hierarchy (AH) is an event-independent framework that describes a system in terms of constraints and purposes across different levels of abstraction (Naikar et al. 2005). As a formative method, AH provides a broader system view, establishing means–end relationships between abstraction levels (Bisantz and Vicente 1994). For instance, Son et al. (2019) applied AH levels to petrochemical procedures, revealing a design imbalance that favored physical steps over functional steps. The authors suggest that analyzing AH levels in procedures could inform improved designs supporting performance in variable environments and safety. However, while AH captures the overall system structure, it can oversimplify the nuances of specific task sequences. To address limitations and leverage HTA and AH in investigating WAI/WAD differences, this study proposes a new approach, the Performance Analysis Technique (PAT), that combines HTA and AH to better understand WAI/WAD differences by examining how procedures are used.

Drawing from the framework proposed by Havinga et al. (2018), PAT integrates three analytical dimensions:

1. Normative: Compares WAI and WAD to assess how actual practices align with or deviate from prescribed procedures in everyday scenarios.
2. Descriptive: Uses HTA to detail how work is actually performed, capturing real-world nuances and adaptations that occur during normal operations.
3. Formative: Incorporates AH to inform the design of new procedures and safety systems; reveal domain-independent functional structures; identify constraints and possibilities; and guide the development of work practices aligned with environmental demands.

In this paper, we introduce PAT and demonstrate its efficacy in exploring WAI/WAD differences using a common task in an oil and gas facility. The descriptions and analyses provided by PAT can assist in formulating strategies to better align worker performance with written procedures, whether that involves having workers adjust their behavior or changing procedures to better support task performance. Through this approach, PAT contributes to the broader goal of enhancing safety and efficiency in high-hazard industries by providing a more nuanced understanding of the realities of everyday work.

2 | Materials and Methods

PAT integrates HTA with AH to provide a comprehensive understanding of both task execution and system functionality.

TABLE 1 | Summary of steps to formulate PAT.

Step	Description	Purpose
1. Create WAI-HTA	Develop HTA based on SOPs and expert interviews	Represent how the task should be performed
2. Create WAD-HTA	Analyze actual task performance	Identify how the task is actually performed
3. Develop AH	Break down work system into abstraction levels	Map goal-means relationships in the system
4. Integrate HTA and AH	Combine workflow analysis with means-end relationships	Create the PAT framework
5. Analyze using PAT	Identify divergences between WAI and WAD, assess impacts	Gain insights into task performance and system goals

Abbreviations: AH, Abstraction Hierarchy; HTA, Hierarchical Task Analysis; PAT, Performance Analysis Technique; SOPs, standard operating procedures; WAI, Work-as-Imagined.

The methodology described here demonstrates the process undertaken to create PAT, from analyzing WAI and WAD through HTAs, to developing an AH, and finally combining these elements into the integrated PAT framework. While future applications of PAT may not require this full development process, understanding its origins provides valuable context for its theoretical foundations and practical applications. Table 1 summarizes the key steps used to formulate PAT, providing an overview of the methodology.

To demonstrate the proposed approach of combining HTA and AH to develop PAT, a column flushing (CF) task was used. CF is commonly used on three-phase separation systems, which separate oil well fluids into gas, water, and oil components (Son et al. 2019). Usage data were collected in a high-fidelity simulator of an offshore oil production platform used for training purposes. Workers were observed as part of a larger study investigating deviations. Video recordings from cameras attached to workers' hard hats captured CF task execution data. The CF task required draining gas and liquid from a column attached to a three-phase separation vessel. Specifically, the CF task enables verification that fluid levels are displayed accurately, an essential safety mechanism for the three-phase separation system. Figure 1 shows the standard operating procedure (SOP) example. When interacting with typical SOPs, workers are supposed to initial the line next to each step number after completing the step. Additionally, Step 7 of Figure 1 has hazard information to take precautions before proceeding to the step. Therefore, by design, the workers must complete the assigned tasks by reading and completing one step at a time.

This CF procedure was utilized to iteratively develop an HTA, following similar approaches leveraged in other studies (Ashour et al. 2021; Razak et al. 2019). This HTA aimed to represent WAI, capturing the procedural steps as outlined in Figure 1. The first step in developing the WAI-HTA involved the identification of high-level subtasks. This step was done by incorporating the HTA principles/protocols (Stanton 2006) with the results from subject matter expert interviews and task observations through video recordings. Furthermore, the creation of WAI-HTA was followed by the analysis of each subtask to determine the necessary lower-level subtasks and action plans. Through this approach, the HTA was developed to encompass the multilevel procedural workflow for the CF task as prescribed in the procedure.

To produce HTAs representing WAD, videos captured using head-mounted cameras were analyzed using a coding framework developed by Mohammed Ashraf et al. (2021). This allowed comparison of actual worker behavior (WAD) to procedural steps (WAI) based on three attributes that reflected the worker's adherence to each step within a procedure: (1) Skip—whether the step was skipped or performed; (2) Order—whether the step was performed in the order specified by the procedure; and (3) Action—whether the step was completed accurately as described in the procedure. Gaps between WAD and WAI could then be identified and categorized based on differences between WAI and WAD for these attributes.

Four different researchers (three undergraduate students and one PhD student) including the first author applied the coding framework through an iterative consensus-building process. Each researcher independently analyzed and coded the CF task. The team then convened to discuss any coding discrepancies, followed by consensus-building sessions to resolve disagreements through extensive discussion and data review. The consensus exercise concluded once full agreement was reached among all coders, ensuring that the final codes reflected a comprehensive and shared understanding of the data. This rigorous coding process enhanced the reliability of applying the framework to categorize WAD versus WAI, allowing for a thorough comparison of WAI and WAD. The coded videos were leveraged to produce HTAs representing WAD.

To understand why WAI–WAD differences occurred and assess whether deviations were adaptive, an AH was developed for the CF task. The AH framework decomposes the work system into hierarchical levels from high-level functional purposes to low-level physical processes, revealing goal–means relationships that show how lower-level actions connect to higher-level goals (Bisantz and Vicente 1994; Naikar et al. 2005). Following the approach by Son et al. (2019, 2020) for analyzing procedural systems in petrochemical facilities, the CF task was mapped across four abstraction levels: system goals (overall three-phase separation system objectives), operational goals (specific CF task objectives), task goals (functional work chunks), and step goals (individual procedural actions). This structure enables evaluation of whether operator adaptations align with or diverge from overall system purposes.

3 | Results

3.1 | Work-as-Imagined HTA

Figure 2 represents the WAI-HTA including multilevel subtasks derived from the interviews and observations of CF task experts.

	Signoff	Operation Step
1.	____	Have CRO place ILIC - 101 in Manual Control.
2.	____	Have CRO communicate when controller is in Manual.
3.	____	Close manual column valve M101 - 9. Lower isolation valve on level column.
4.	____	Close manual column valve M101 - 11. Upper isolation valve on level column.
5.	____	Remove plug.
6.	____	Open drain valve on bottom of float cage.
7.	____	Drain fluids into a bucket with secondary containment. Trapped pressure may be present. Uncontrolled pressure release could result in bodily injury or death. Wear gloves and safety glasses.
8.	____	Remove plug and open vent on top of float cage and vent to a location away from any personnel. Slowly open vent--releasing pressure a little at a time. *Note: This will verify that all fluids have been drained.*
9.	____	Close the vent valve and re-install plug.
10.	____	Close the drain valve and re-install plug.
11.	____	Open manual column valves M101 - 11. Upper isolation valve on level column
12.	____	Open manual column valves M101 - 9. Lower isolation valve on level column
13.	____	Observe that the fluid rise and that the ILIC returns to a normal operating condition.
14.	____	Dispose of fluids collected from performing the task by dumping in Wet Oil Tank.

FIGURE 1 | Standard operating procedure (SOP) of the column flushing task.

3.2 | Work-as-Done HTA

Figure 3 represents the WAD-HTA. As indicated by the yellow boxes, Step 2 was completed after Step 3, indicating an out-of-order sequence. Similarly, Step 16, which involved disposing of fluids into the wet oil tank, was not observed, resulting in it being coded as skipped, denoted by the orange box. Additionally, during Step 8.2, the worker turned the valve rapidly instead of slowly as instructed. Therefore, Step 8.2 was coded as "step not done properly," as shown by the red box when checked for the Action attribute. Despite these deviations from the prescribed procedure regarding the Skip, Order, and Action attributes, the worker successfully completed the task of column flushing without any incidents in all three instances.

3.3 | Abstraction Hierarchy of the Column Flushing Task

Figure 4 presents the AH for the CF task, showing the goal–means relationships across four hierarchical levels. At the highest level, the *system goal* represents the overall goal of the three-phase separation system which includes the safe operation for both system and personnel, producing good quality products, and an efficient separation process (Son et al. 2020). Moving to more specific levels, the *operational goal* is to flush the columns regularly to maintain proper indication of the oil/water level within the tank vessel. This operational goal must be met to achieve the system goals. The operational goal is accomplished through several *task goals*, which represent

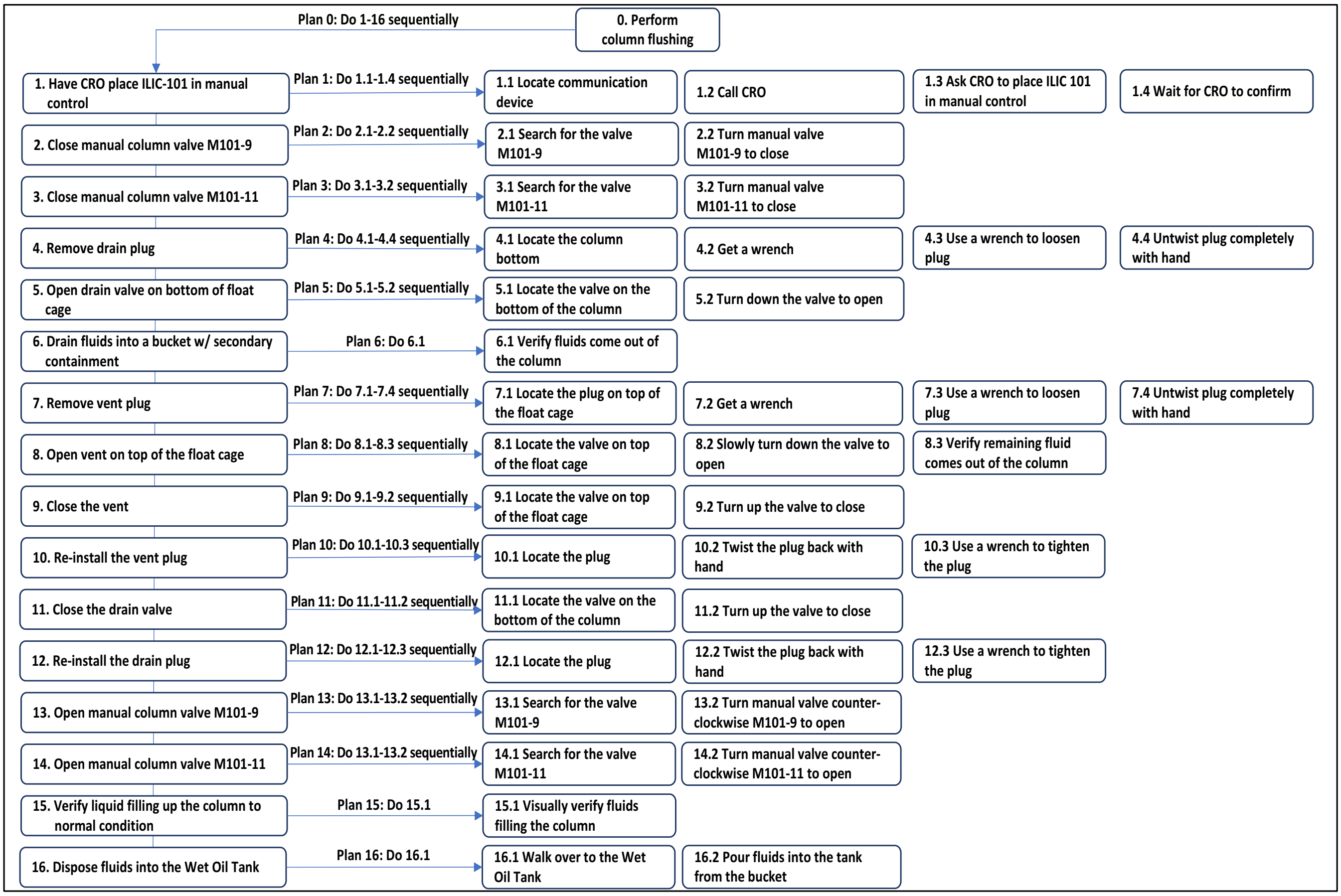

FIGURE 2 | Work-as-Imagined HTA for the column flushing task.

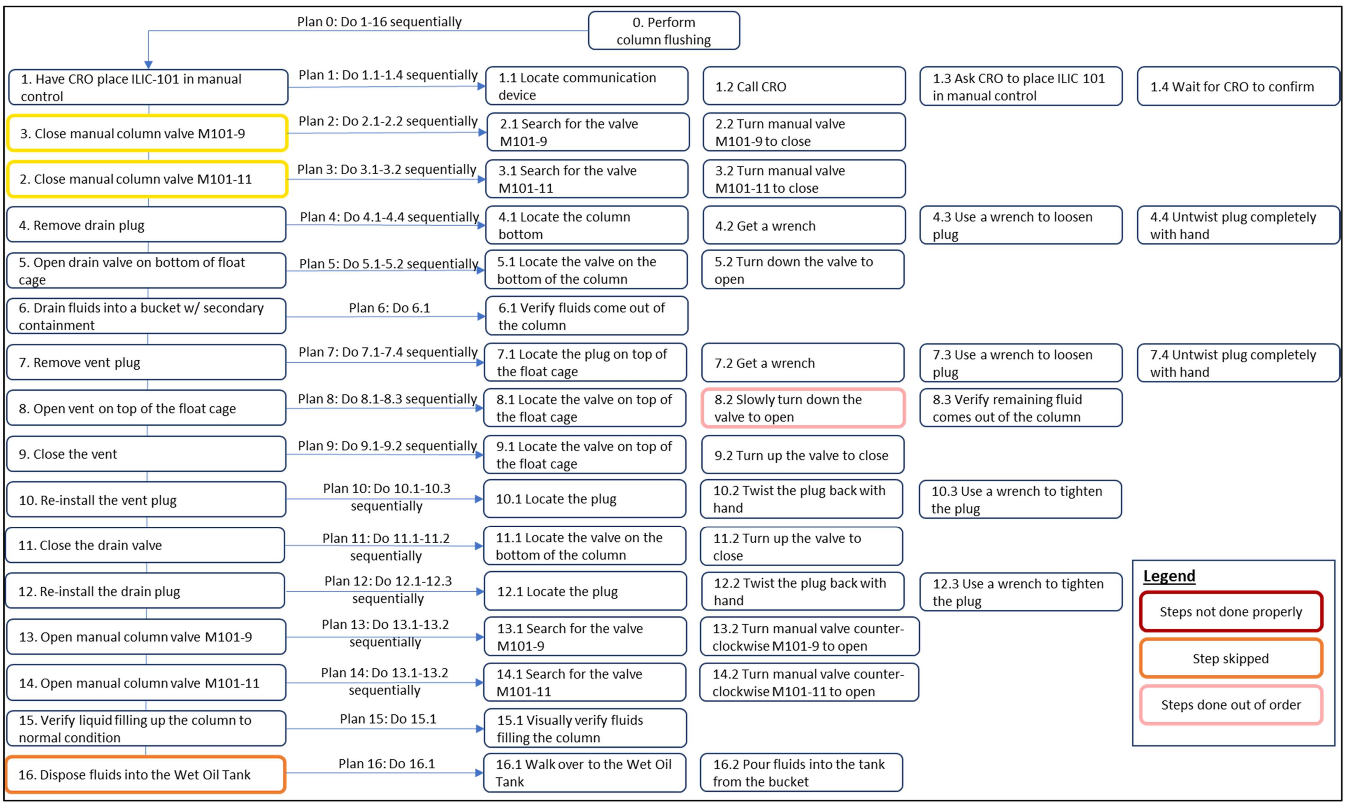

FIGURE 3 | Work-as-Done HTA for the column flushing task.

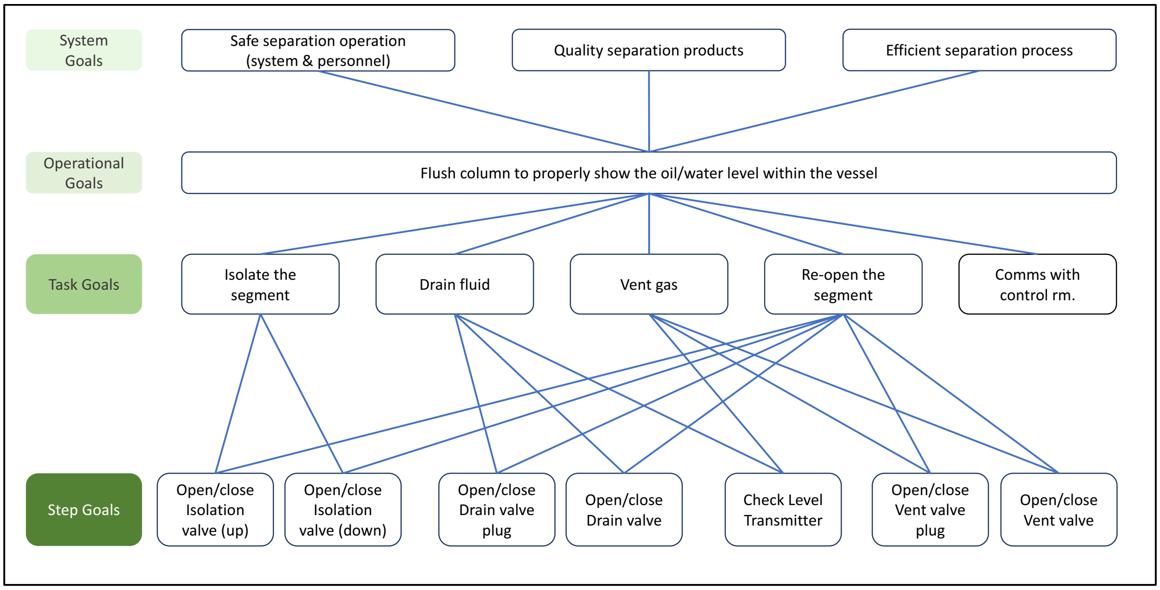

FIGURE 4 | Abstraction Hierarchy of the column flushing task.

functional chunks of the overall procedure. For instance, the task goal "reopening column segment" encompasses the step goals of reopening all the valves and plugs that were closed during the previous task goal. At the most granular level, *step goals* correspond to individual procedural actions. For example, an SOP prescribes step-by-step instructions such as "close vent valve then close vent plug." However, the hierarchy reveals that the same task goal could potentially be accomplished through alternative step sequences, provided the higher-level goals are maintained.

3.4 | Performance Analysis Technique (PAT)

Figure 5 shows the CF task represented using PAT where the AH and WAD-HTA were combined. The vertical section indicated by the green boxes displays the various levels of goals within the AH. At the topmost level is the *system goal*, encompassing three subgoals: ensuring the safe operation of the gas separation system while prioritizing worker safety, maintaining high-quality separated products, and optimizing the separation process. Similarly, each abstraction level features corresponding subgoals represented horizontally. Finally, at the *step goal* level, the corresponding subgoals are represented by numbers that correspond to the steps shown in HTA-WAD (refer to Figure 3). Like Figure 3, the yellow box indicates the steps done in the wrong order, and the red box corresponds to the step that was completed incorrectly.

Utilizing PAT, Figure 5a shows that Steps 2 and 3 were completed in an order different from the prescribed procedure (see Steps 2 and 3 in Figure 3). The HTA-WAD component of PAT identifies that these steps were done out of order. With AH integrated into PAT, it assesses how this deviation impacts both the immediate and broader goals of the system. Despite this deviation, the step, task, operational, and system goals were achieved, and the procedure is considered to be completed successfully. In this case, PAT allows us to assess this divergence as acceptable, as it did not negatively impact the overall system goals.

HTA alone might suggest that the deviation of doing the steps out of order is not acceptable, although the worker managed to isolate the segment. Conversely, AH alone does not specify the sequence of steps, but rather only provides information on the means to achieve goals. PAT combines these elements to offer a holistic understanding of where divergences between WAI and WAD occur and whether they are acceptable or not based on their impact on the overall system.

Similarly, when analyzing Step 8.2 (venting the gas) from Figure 5b, PAT identified another instance of deviation between WAI and WAD at the *step goal* level. The PAT analysis (Figure 5b) indicates that this deviation has cascading implications on the broader system goal of ensuring a safe separation operation. Despite Step 8.2 seemingly appearing to be accomplished, with both the step, task and operational goals met at face value, the critical factor is that the step was carried out inaccurately—specifically, the worker opened the valve rapidly to release the pressurized gas instead of opening it slowly to vent the gas safely. Rapid opening could potentially harm the worker and damage the relief valve and hence not meet the *system goal* of safe separation operation. In this case, PAT allows us to assess this divergence as unacceptable due to its potential negative impact on system safety.

This discrepancy underscores the nuanced nature of system goals, which must be met with correctness to maintain the safety and integrity of the overall system and its personnel. By identifying and assessing these divergences, PAT provides valuable insights into how task performance might gradually shift over time. For instance, if the rapid valve opening in Step 8.2 becomes a common practice among workers due to time pressures or misunderstanding of its importance, it could lead to a gradual erosion of safety practices. Similarly, the reordering of Steps 2 and 3, while acceptable in this instance, could potentially lead to more significant deviations if it becomes a habitual practice without proper assessment of its impact in varying scenarios. Both situations demonstrate the concept of normalization of deviance (Vaughan 1996), specifically through practical drift, in which actual practices slowly deviate from

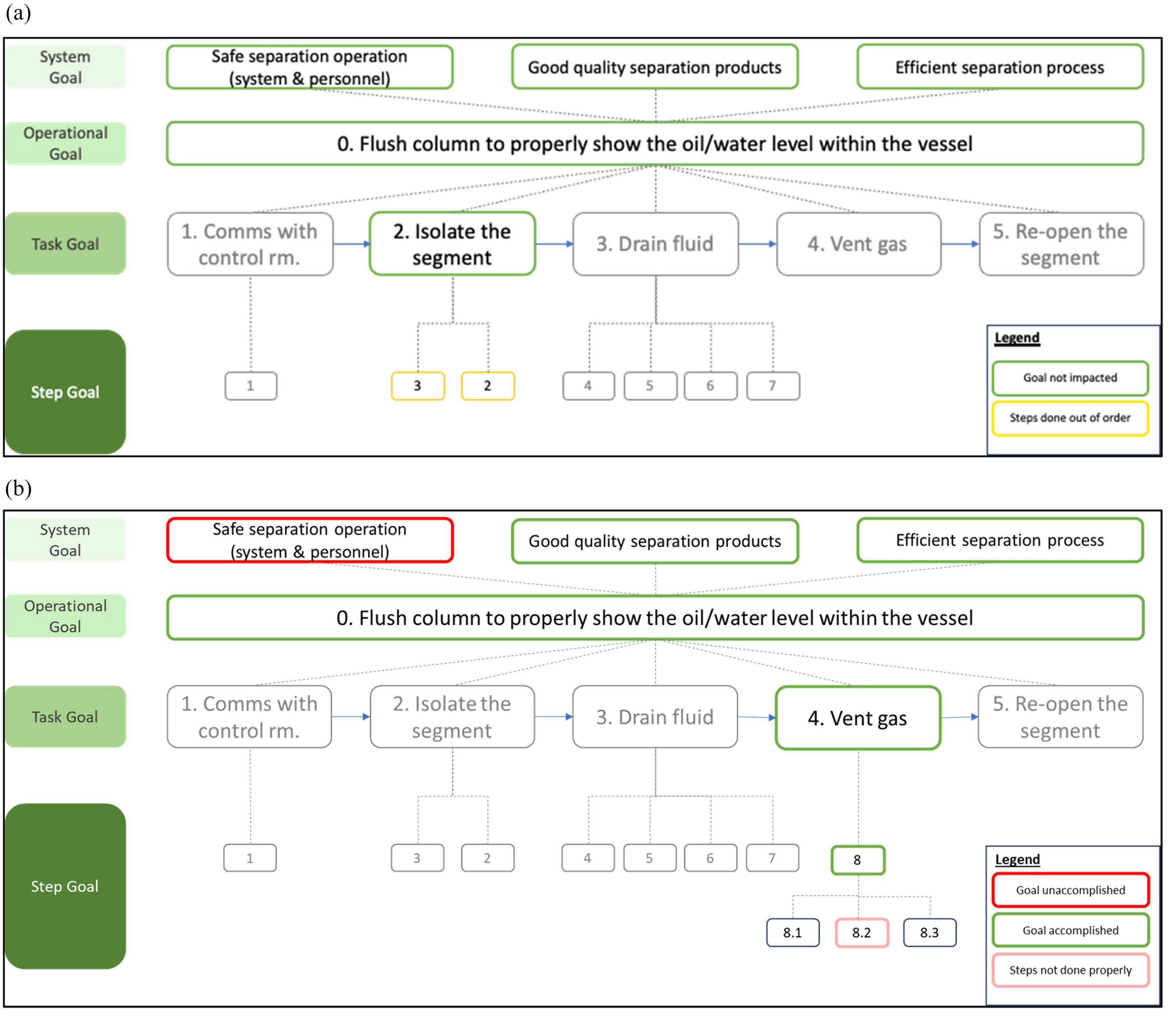

FIGURE 5 | (a) PAT example of steps done out of order during the column flushing task. (b) PAT example of a step not done properly during the column flushing task.

established procedures over time through local adaptations (Snook 2000). In the case of Step 8.2, we see how time pressures could lead to shortcuts, while the reordering of Steps 2 and 3 shows how seemingly innocuous changes could become problematic if not properly managed.

Finally, the analyses provided by PAT can potentially assist in formulating strategies to better align worker performance and written procedures. In the case of Steps 2 and 3, where the deviation was found to be acceptable, organizations might consider revising the written procedure to allow for this flexibility, provided it does not compromise safety in other scenarios. This adjustment would align the procedure with effective work practices. Conversely, for Step 8.2, where the deviation was unacceptable, the focus should be on reinforcing the importance of slow valve opening through targeted training, clearer instructions in the procedure, or even engineering controls that prevent rapid valve operation.

4 | Discussion

4.1 | Overview of PAT

PAT integrates HTA and AH, addressing the growing emphasis in safety research on investigating normal work and success, rather than solely focusing on accidents and failures (Hollnagel 2018; Sujan et al. 2017). This integration leverages the complementary strengths of both methods. HTA provides structured workflow analysis and hierarchical task sequencing, while AH contributes means–end abstraction level relationships and hierarchical functional understanding (Naikar et al. 2005). While HTA demonstrates the linkage between goals and subgoals, it tends to be highly sequential, lacking insights into the consequences of skipping steps, doing them in a different order, or completing the steps inaccurately. It may also overlook unanticipated events (Salmon et al. 2010; Stanton 2006). Conversely, the event-independent AH framework reveals functional connections but has limited application in analyzing WAI–WAD deviations (Bisantz and Vicente 1994; Naikar et al. 2005). By integrating these methods, PAT offers a more holistic understanding of the system, highlighting the interplay between its components, and identifying where specific actions are done and how those actions impact different levels of the system. This combined approach facilitates deeper examination of workflows and procedures, providing insights into gradual shifts over time that could potentially accumulate and lead systems toward unsafe states (Bergström et al. 2015; Dekker 2003, 2016). The enhanced understanding of both system functions and task-level deviations enables evaluation of whether operator adaptations align with or diverge from overall system purposes. Such insights may inform the design of safety management systems and methods to improve performance and safety. Additionally, this integrated approach supports the design and writing of procedures that align more closely with what the workers do to complete their tasks (WAD), rather than relying solely on a perception or expectation of how tasks should be performed (WAI).

4.2 | Comparison With Other Methods

To further illustrate the contributions of PAT and how it addresses the gaps in existing methodologies, such as HTA and AH, for studying everyday work, Table 2 provides a comprehensive comparison of PAT with its constituent methods, HTA and AH. This comparison highlights how PAT integrates and expands upon the strengths of both methods while addressing their individual limitations.

Particularly noteworthy is PAT's enhanced ability to capture and analyze the realities of everyday work, balancing both Safety I and Safety II perspectives, and providing a more holistic approach to understanding and improving work practices in complex systems. In recent years, the concept of Safety II has gained significant traction in safety research and practice (Peres and Hendricks 2024; Provan et al. 2020; Sarvari et al. 2024; Sujan et al. 2017). Unlike traditional Safety I approaches that focus primarily on preventing failures, Safety II emphasizes understanding and enhancing the adaptations and variability that characterize successful everyday work (Hollnagel 2018). This shift in perspective recognizes that safety is not merely the absence of failures, but rather the presence of consistent successful outcomes despite varying conditions. PAT incorporates this Safety II paradigm by providing a structured approach to investigate and understand the often-overlooked aspects of normal operations, where workers successfully navigate complexities and adapt to changing conditions.

Similarly, compared to other methods for studying everyday work, such as Cognitive Work Analysis (Vicente 1999), the Resilience Analysis Grid (Hollnagel 2011), or The Functional Resonance Analysis Method (Hollnagel 2017) PAT offers a relatively simpler mapping between task-level activities and system-level goals. This makes it particularly suited for analyzing and improving SOPs in high-risk industries.

4.3 | Advantages of PAT

The integration of HTA and AH in PAT offers several advantages over existing methods:

(1) *Multilevel analysis:* PAT enables analysis at both task and system levels, addressing the challenge of multilevel analysis in safety research (Le Coze 2015; Rasmussen 1997).

(2) *Visibility of adaptations:* By mapping task steps to system goals, PAT makes adaptive practices more visible, addressing a key challenge identified in everyday work investigations (Cook and Woods 1994; Rankin et al. 2014).

(3) *Balancing Safety I and Safety II perspectives:* PAT facilitates the identification of instances where strict procedural adherence is necessary (Safety I) and where flexibility can be allowed to enable safe adaptations (Safety II) (Hollnagel 2018; Provan et al. 2020).

(4) *Operationalization of abstract concepts:* PAT provides a structured way to operationalize abstract safety concepts through the AH component, addressing a longstanding challenge in safety science (Leveson 2012; Patriarca et al. 2018).

(5) *Translation of findings into interventions:* The integrated approach of PAT facilitates the translation of observations into concrete safety interventions, particularly in redesigning procedures or safety management systems (Carayon et al. 2015; Hendricks and Peres 2021).

4.4 | Application and Implications for Safety Management

The application of PAT to the CF task demonstrates its potential in revealing when, where, and how adaptations and deviations occur between prescribed procedures and actual worker practices.

(a) Reordering of Steps 2 and 3:

- Observation: The prescribed sequential order was not strictly adhered to (Figure 5a), yet this deviation did not compromise the overarching system goals.
- Implication: This example illustrates how workers successfully adapt to achieve desired outcomes, aligning with a Safety II perspective. It suggests that some procedural flexibility might be beneficial and that rigid adherence to step order may not always be necessary for safety or efficiency.

(b) Deviation in Step 8.2:

- Observation: The erroneous execution of this step, despite the overall successful completion of the CF task, revealed the potential to impede the realization of specific system goals (Figure 5b).
- Implication: This rapid valve opening aligns more with Safety I concerns, where strict adherence to procedures is crucial for maintaining safety. It indicates areas where additional training, engineering controls, or stricter monitoring might be necessary to prevent potentially hazardous deviations.

These examples demonstrate how PAT can identify instances where Safety I or Safety II perspectives may apply, allowing for

TABLE 2 | Comparison of Hierarchical Task Analysis (HTA), Abstraction Hierarchy (AH), and Performance Analysis Technique (PAT) in analyzing work practices and safety.

Methodology	Hierarchical Task Analysis	Abstraction Hierarchy	Performance Analysis Technique
Focus	Task decomposition and sequencing	System functions and goals	Integration of task-level activities and system-level goals
Advantages	• Provides a detailed breakdown of tasks and subtasks • Shows clear task sequences • Useful for procedure development • Familiar to many practitioners	• Reveals functional connections in the system • Shows relationships between different levels of abstraction • Helps understand system goals and constraints • Event-independent framework	• Integrates task-level and system-level analysis • Reveals WAI–WAD deviations and their impacts • Balances Safety I and Safety II perspectives • Facilitates understanding of adaptations • Supports procedure optimization • Provides a holistic view of work and system goals
Disadvantages	• May overlook unanticipated events • Focuses on prescribed work, not adaptations • Limited in showing functional relationships • May not capture system-level goals	• Limited application in analyzing WAI–WAD deviations • Doesn't show task sequences • Can be complex to develop and interpret • May not capture specific task details	• May be more time-consuming to apply than individual methods • Requires understanding of both HTA and AH • Potential for investigator bias in interpretation • May be challenging to implement in Safety I focused organizations • Validation in diverse settings still needed
Alignment with Safety Perspectives	• Primarily aligns with Safety I	• Can support both Safety I and Safety II, but more aligned with Safety II	• Explicitly balances Safety I and Safety II perspectives
Ability to capture adaptation	• Limited—focuses on prescribed procedures	• Moderate—can show functional flexibility, but not specific adaptations	• High—explicitly maps deviations and adaptations to system goals
Suitability for procedure review	• Moderate—Good for improving task sequences and identifying inefficiencies in step order	• Limited—Provides insight into system functions but does not directly address specific procedures	• High—Enables comprehensive procedure improvement by considering both task sequences and their alignment with system goals
Ability to understand everyday work	• Primarily captures prescribed work (WAI)	• Captures system-level aspects of work, but may miss task-level details of everyday practice	• Captures both task-level details and system-level aspects, revealing how everyday work (WAD) relates to and deviates from prescribed work (WAI)

a more comprehensive analysis that assesses the impact of deviations on overall system goals. By incorporating both perspectives, organizations can balance the need for procedural compliance with the recognition of beneficial adaptations, ultimately leading to more resilient and effective safety practices (Provan et al. 2020).

The integrated framework of PAT facilitates the assessment of deviation impacts on goal achievement, enabling more holistic optimization and evaluation of existing procedures. This approach supports safety managers in:

(1) Identifying areas where procedures may be overly rigid and could benefit from allowing more operator discretion.

(2) Recognizing critical points in processes where strict adherence is essential for safety.

(3) Developing more effective training programs that address both the need for procedural compliance and the skills required for safe adaptation.

(4) Designing safety management systems that are better aligned with the realities of everyday work.

By revealing relationships between prescribed work, actual performance, and high-level goals, PAT enables a more nuanced understanding of work practices. This understanding is crucial for developing safety management strategies that are both effective and resilient in the face of the complexities and variabilities inherent in real-world operations (Dekker 2006; Hollnagel et al. 2006).

4.5 | Limitations

While the application of PAT was demonstrated through a case study involving a CF task, further research should evaluate PAT across diverse domains and tasks. Additional opportunities exist to refine the technique and validate its utility for revealing WAI–WAD differences. Longitudinal studies could reveal how procedures, practices, and systems mutually evolve over time. Future research may also focus on applying PAT across diverse industries and contexts to further validate its effectiveness and refine its methodology. Additionally, exploring how PAT can be integrated with existing safety management systems and risk assessment processes could enhance its practical impact.

5 | Conclusion

A key contribution of PAT is its ability to facilitate nuanced examination of deviations, enabling safety managers to determine when strict procedural adherence is warranted (Safety I) versus when flexibility can be allowed to leverage safe adaptations (Safety II). This balanced approach supports the development of more resilient and effective safety practices in complex sociotechnical systems. Additionally, the development and application of PAT represent a significant step forward in safety research methodology. By providing a structured approach to analyzing everyday work in the context of safety, PAT addresses a critical gap in the field. As safety science continues to emphasize the importance of understanding and improving normal work practices, PAT stands as a promising tool for advancing our understanding of safety in practice.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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