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Safety based dynamic uncertainty reduction to increase safety performance in aviation industry

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A B S T R A C T

There is a lot of evidence regarding air flight accidents caused by human error, especially air traffic controllers (ATC). On the other hand, the principle of work safety through safety performance can help organizations reduce the number of work accidents and create zero accidents in the aviation industry. This research aims to analyze the effect of leadership on safety culture and safety performance by investigating the mediating role of Safety Based Dynamic Uncertainty Reduction (SDUR) as an integral aspect in safety research. A total of 214 respondents were involved in this research. The analysis technique used in this study is Partial Least Square-Structural Equation Modeling (PLS-SEM). The results showed significant effects of leadership on safety culture and safety performance. The mediating analysis also reveals the significant effects of SDUR in strengthening the impact of leadership to safety performance. As implications, SDUR can be considered as an effective strategy in improving Safety Performance in the workplace.

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1. Introduction

The safety culture has become a major concern in various industries, particularly those requiring a high level of safety such as the aviation, oil and gas, and petrochemical industries (Stemn et al., 2019). One significant factor that has a considerable influence in building a safety culture is leadership (Roughton et al., 2019). Good and effective leadership can provide the proper direction and guidance for employees to comply with safety rules and practice safe behaviors at work. However, there are dynamics of uncertainty in the industry in general and in potentially risky workplaces, which can affect how leadership directs and manages safety aspects (Harsini et al., 2021; Guldenmund, 2000). Safety culture is a crucial aspect within an organization as it can significantly impact employee performance and productivity. Leadership also plays a critical role in shaping safety culture. Huang et al. (2018) confirmed that effective leadership can have a positive impact on workplace health and safety (H&S). Furthermore, actions from leaders that demonstrate a concern for H&S can increase employee motivation and performance, thus minimizing workplace accidents and injuries. Therefore, it is essential for organizations to pay attention to and enhance the role of leadership in creating and maintaining a safety culture within their workplace.

Leadership in safety is a critical aspect of managing dynamic uncertainty and enhancing safety performance in organizations. According to Zohar and Luria (2005), leaders who are effective in creating a safe work environment can adapt to the ever-changing and unpredictable nature of work, and thus, can better anticipate, prevent, and manage accidents and incidents. Moreover, research has shown that leadership behaviors such as setting expectations, communicating safety standards, and providing feedback can significantly impact the safety climate of an organization (Hofmann & Stetzer, 1996). Therefore, leaders need to be proactive in creating a culture of safety, where employees are empowered to take responsibility for their own well-being and are given the necessary training and resources to identify and control hazards at work. The effectiveness of leadership in promoting safety is not only important for the well-being of employees but also for the financial performance

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of the organization (Zohar, 2002). In summary, leadership plays a crucial role in managing dynamic uncertainty and improving safety performance, and organizations must invest in developing effective leaders who can create a culture of safety.

Therefore, it is important to study the effects of the influence of leadership on safety culture in the context of dynamics of uncertainty and safety performance. The objective of this study is to evaluate the relationship between leadership, safety culture, and safety performance in uncertain situations. This study applies a quantitative approach and uses survey data to collect information from employees in the petrochemical industry. This study investigates the role of Safety Based Dynamic Uncertainty Reduction (SDUR), as a concept that bridges and integrates relevant research from organizational management and safety management. The concept of SDUR as a series of future-oriented activities in which an organization systematically makes changes to its operational routines in pursuit of improving safety performance. The concept of SDUR is important because hazardous operations in work arise from changes in technology, evolution of environmental requirements, and workforce demographics. A positive organizational climate and supported by a good management system in an organization that always adapts to external conditions, so that every individual in the organization will adapt to this situation.

2. Literature Review and Hypothesis

Leadership is a key factor in developing safety culture in the workplace. According to Goh et al. (2015), leadership creates an environment that supports safety culture in the workplace. The number of studies that examine the relationship between leadership and safety culture is increasing, as awareness of the importance of safety culture in the workplace is growing. The shallow effects of bad behavior can cause serious injuries or even death (Lapierre et al., 2016). When dealing with the dynamics of uncertainty, leadership becomes more critical in maintaining a safety culture. Research shows that uncertainty is inherent in certain sectors, such as construction and mining, which carry high risks of injury and death (Nakamura et al., 2020; Nielsen & Gottlieb, 2017). According to Nielsen and Gottlieb (2017), leadership in uncertain situations requires adaptability and openness to eliminate uncertainty and maintain a safety culture. Previous studies also showed that leadership plays a crucial role in workplace safety performance. The effectiveness of leadership in creating and maintaining a safety culture has an impact on safety performance (Passmore et al., 2020). According to Passmore et al. (2020), effective leaders can assess safety-related risks and provide proper guidance to their workforce on appropriate safety practices. According to a study by Sari and Nita (2019), safety culture has a significant influence on safety performance. Safety culture refers to the safety culture implemented within an organization, where there is a collective awareness of the importance of safety in carrying out work activities. In addition, safety performance includes all activities carried out to prevent accidents and ensure safety in the workplace. Therefore, it is essential for organizations to pay attention to and enhance their safety culture to maintain good safety performance and prevent harmful work accidents. Moreover, various studies have demonstrated that good leadership can contribute to the development of a positive safety culture in the workplace. However, the mechanisms or factors that mediate this relationship are still not thoroughly understood. In a recent study, researchers found that Safety Based Dynamic Uncertainty Reduction (SDUR) serves as an important mediator in influencing the relationship between leadership and safety culture. Previous research indicates that strong leadership has been proven to strengthen SDUR values, which in turn strengthens safety culture in the workplace (Guzmán-Valenzuela et al., 2021). Therefore, understanding the relationship and factors involved in influencing safety culture in the workplace is crucial in optimizing a safe and productive work environment.

Li et al. (2018) stated that the relationship between leadership and safety performance can be mediated by Safety Based Dynamic Uncertainty Reduction (SDUR). Research shows that more effective leaders can increase SDUR, which in turn can enhance safety performance. Therefore, SDUR is a crucial mediating factor in establishing a positive relationship between leadership and safety performance in the workplace. This study highlights the importance of safety-oriented decision-making in improving company safety performance. Research conducted by Aksornchindarat et al. (2018) has found that Safety Culture can mediate the relationship between Leadership and Safety Performance. In the study, Safety Culture was measured using Employee Perception Safety Culture Survey, while Leadership was measured by Leadership Behavioral Scale and Safety Performance was measured by accident rates. The study found that there was a positive relationship between Leadership and Safety Performance which was mediated by Safety Culture. This implies that Safety Culture plays an important role in influencing Safety Performance within an organization. Therefore, organizational management should pay attention to and improve Safety Culture to enhance Safety Performance. Safety culture pertains to the shared values, attitudes, beliefs, and norms among an organization's members concerning safety. The essential safety management components of Safety Based Dynamic Uncertainty Reduction (SDUR) hold significance. Evidence depicts safety culture as a mediator that connects SDUR to safety performance in organizations, emphasizing the importance of cultivating a positive safety culture to enhance safety performance. The organization's safety must receive priority, adopting secure practices and promoting a constructive safety culture to ensure the safety of all related to the organization, including employees. Leadership is a critical element in creating and maintaining a strong safety culture and improving safety performance in organizations. According to research conducted in examining SDUR showed that effective safety leadership involves establishing clear safety policies, setting safety performance goals, providing resources and training for employees, promoting open communication, and leading by example. Additionally, safety leaders must emphasize the importance of safety and consistently reinforce safe behaviors and practices throughout the organization. Studies have shown that organizations with strong safety cultures, driven by effective leadership, have fewer safety incidents, lower injury rates, and improved overall safety performance. Accordingly, following hypotheses were proposed to examine direct and indirect effects of the relationship between constructs:

H_1: *Leadership has a significant influence on Safety Culture.*
H_2: *Leadership has a significant influence on Safety Based Dynamic Uncertainty Reduction.*
H_3: *The Safety Based Dynamic Uncertainty Reduction has a significant influence on safety culture.*
H_4: *The Safety Based Dynamic Uncertainty Reduction has a significant impact on safety performance.*
H_5: *Safety culture has a significant impact on safety performance.*
H_6: *Safety Based Dynamic Uncertainty Reduction serves as a mediator between leadership and safety culture.*
H_7: *Safety Based Dynamic Uncertainty Reduction mediates the relationship between leadership and safety performance.*
H_8: *The Safety Culture serves as a mediator in the relationship between leadership and safety performance.*
H_9: *Safety Culture mediates the relationship between Safety Based Dynamic Uncertainty Reduction and Safety Performance.*
H_{10}: *Safety Culture strengthens the relationship between leadership and safety Performance through Safety Based Dynamic uncertainty reduction (SDUR).*

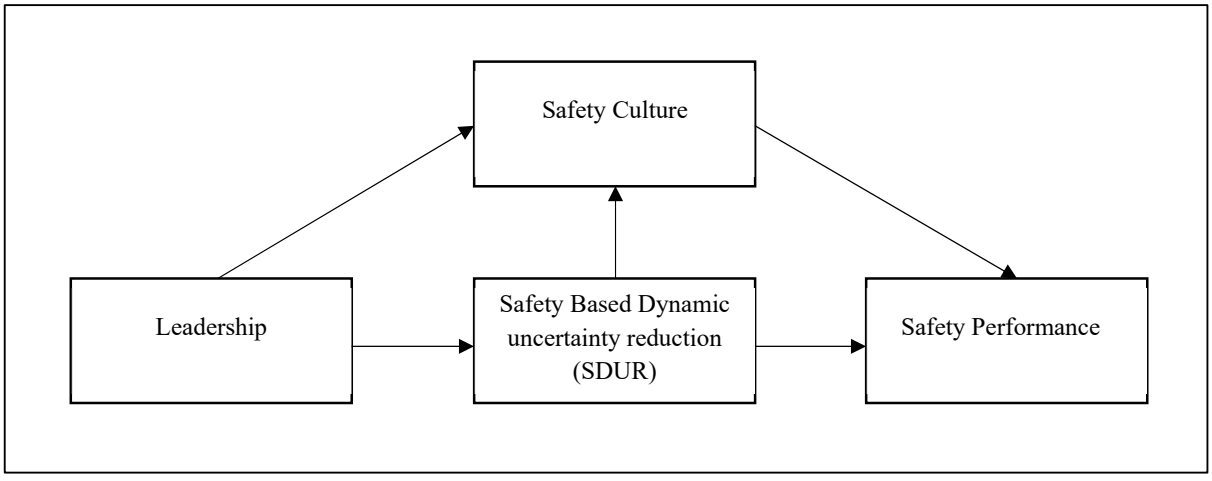

Fig. 1. Conceptual framework

3. Research Method

This research was conducted on ATC (Air traffic controller) employees at Indonesian International airports, under the control of the Indonesian DNP (Air Navigation Service). The sampling technique was conducted by using stratified random sampling, with a minimum sample determined by the Slovin method. A total of 214 respondents were involved in this research. To obtain the necessary data, the researcher distributed questionnaires, namely providing a list of questions to respondents and respondents choosing several alternative answers that were already available. The data collection method in this study was to use personally administered questionnaires, in which the researcher delivered the questionnaires to the respondents themselves and took the questionnaires that had been filled in by the respondents themselves. The analysis technique used in this study is the structural equation modeling (SEM) through Partial Least Square (PLS) or PLS-SEM technique.

4. Results

The analysis to examine loading factors as shown in Table 1 showed the loading factors for all variables used in this study, namely LEAD for leadership, SDUR for Safety Based Dynamic Uncertainty Reduction, SC for safety culture and SP for safety performance. The analysis showed that all items have loading values >0.7, except LEAD3 (0.625), SDUR1 (0.588), SC8 (0.665) and SP3 (0.679). These items were removed from further analysis as their loads were below the acceptable standard of 0.7.

The reliability testing showed the values for all variables used in this study, by presenting the value of Cronbach's Alpha, rho_A, Composite Reliability and Average Variance Extracted (AVE). The results showed that the variable of leadership was reliable (Cronbach's Alpha=0.942; rho_A= 0.948; Composite Reliability = 0.952; Average Variance Extracted=0.690). The results also showed Cronbach's Alpha value of reliability for Safety Based Dynamic Uncertainty Reduction (SDUR) was 0.763, rho_A of 0.815, Composite Reliability of 0.844, and Average Variance Extracted (AVE) of 0.580. Moreover, the values of Cronbach's Alpha, rho_A, Composite Reliability, and Average Variance Extracted (AVE) for Safety Culture and Safety Performance were also considered as reliable (Table 2).

Table 1
Standard Loading Factors

Items	Leadership	SDUR	Safety Culture	Safety Performance
LEAD1	0.775			
LEAD2	0.882			
LEAD3	0.625			
LEAD4	0.881			
LEAD5	0.905			
LEAD6	0.821			
LEAD7	0.839			
LEAD8	0.870			
LEAD9	0.841			
SDUR1		0.588		
SDUR2		0.708		
SDUR3		0.866		
SDUR4		0.850		
SC1			0.790	
SC2			0.846	
SC3			0.747	
SC4			0.793	
SC5			0.786	
SC6			0.751	
SC7			0.861	
SC8			0.665	
SC9			0.853	
SP1				0.721
SP2				0.819
SP3				0.679
SP4				0.762
SP5				0.826
SP6				0.792

Table 2
Reliability and Validity Values

Variables	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Leadership	0.942	0.948	0.952	0.690
SDUR	0.763	0.815	0.844	0.580
Safety Culture	0.924	0.927	0.937	0.624
Safety Performance	0.860	0.869	0.896	0.590

The analysis of hypothesis testing was then performed. Based on the data in Table 3, all five hypotheses related to the effect of leadership on safety culture, Safety Based Dynamic Uncertainty (SDUR), and safety performance are accepted with significant results. This indicates that there is a positive relationship between leadership and these three variables in the context of workplace safety.

Table 3
Hypothesis test (direct effect)

	Hypothesis	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Information
H1	Leadership → Safety Culture	0.341	0.332	0.082	4.140	0.000	Significant
H2	Leadership → SDUR	0.768	0.769	0.042	18.140	0.000	Significant
H3	SDUR → Safety Culture	0.470	0.478	0.074	6.313	0.000	Significant
H4	SDUR → Safety Performance	0.422	0.421	0.087	4.826	0.000	Significant
H5	Safety Culture → Safety Performance	0.393	0.399	0.085	4.646	0.000	Significant

Testing hypothesis 1 reveals that leadership has a significant effect on safety culture with T Statistics of 4.140 and *p*-values of 0.000. This showed that hypothesis 1 was accepted. Hypothesis 2 suggests that leadership has a significant effect on SDUR. The hypothesis is supported as indicated by the sample mean (0.768) and the T statistics (18.140) with a p-value of 0.000. This was in line with Mohamed et al. (2018), a positive relationship between leadership and safety culture can improve workplace safety. This also denotes the critical role of leadership in shaping organizational culture, and the data above suggest that it can play a role in enhancing safety outcomes and uncertainty reduction. The results align with the previous literature, which suggests that effective leadership is crucial for building a strong safety culture and achieving high levels of safety performance (Clarke, 2010, 2015).

Hypotheses 3 and 4 suggest that Safety Based Dynamic Uncertainty Reduction has a significant effect on safety culture and safety performance. The results showed T statistics of 6.313 (SDUR → Safety Culture) and 4.826 (SDUR → Safety Performance) with low p-values (0.000>0.05). The high T statistics and low p-values indicate that the findings are robust and not due to chance. The sample means and standard deviations also demonstrate that the data have a reasonable level of consistency and variation, supporting the reliability of the study. Therefore, organizations should prioritize investing in Safety Based Dynamic Uncertainty Reduction programs that cultivate strong safety culture, performance, and skills. By doing so, they can foster a culture of safety, reduce SDUR, and enhance overall safety performance outcomes.

Hypothesis 5 suggests that safety culture has a significant effect on safety performance. The hypothesis is supported as indicated by the sample mean (0.393) and the T statistics (4.646) with a p-value of 0.000. The results are consistent with previous studies that have shown a positive relationship between safety culture and safety performance (Arezes & Miguel, 2003). Overall, the direct effects demonstrated critical elements of leadership. In a study conducted by Yuanita and Syam (2020), it was also found that leadership can influence safety culture in the workplace. The study demonstrated that transformational leadership has a significant positive impact on safety culture in the workplace. In another study conducted by Mahmood and Khan (2019), it was also found that leadership plays a crucial role in shaping the safety culture in the workplace. The study demonstrated that leadership styles that are employee-oriented such as transformational and transactional leadership are associated with an enhancement of the safety culture in the workplace.

Table 4
Hypothesis test (mediating test)

Hypothesis		Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Information
H6	Leadership → SDUR → Safety Culture	0.361	0.369	0.066	5.488	0.000	Significant
H7	Leadership → SDUR → Safety Performance	0.324	0.326	0.076	4.241	0.000	Significant
H8	Leadership → Safety Culture → Safety Performance	0.134	0.135	0.052	2.593	0.010	Significant
H9	SDUR → Safety Culture → Safety Performance	0.185	0.189	0.042	4.395	0.000	Significant
H10	Leadership → SDUR → Safety Culture → Safety Performance	0.142	0.145	0.032	4.478	0.000	Significant

The analysis also reveals the indirect testing by exploring the role of mediating variable of SDUR (Safety Based Dynamic Uncertainty Reduction) and safety culture. Based on the data provided as shown in Table 4, it can be concluded that there is a significant relationship between leadership, SDUR (Safety Based Dynamic Uncertainty Reduction), safety culture, and safety performance. More specifically, hypothesis 6 suggests that leadership has a significant effect on safety culture through SDUR. The hypothesis is supported as indicated by the sample mean (0.369) and the T statistics (5.488) with a p-value of 0.000. According to Mohamed et al. (2018), a positive relationship between leadership and safety culture can improve workplace safety. Hypothesis 7 suggests that leadership has a significant effect on safety performance through SDUR. The hypothesis is supported as indicated by the sample mean (0.326) and the T statistics (4.241) with a p-value of 0.000. The results are consistent with previous studies that have shown a positive relationship between leadership and safety performance (Chen et al., 2018, 2019). Hypothesis 8, on the other hand, suggests that safety culture mediates the relationship between leadership and safety performance. The hypothesis is supported as indicated by the sample mean (0.135) and the T statistics (2.593) with a p-value of 0.010. The findings are like other studies that have demonstrated that safety culture plays a vital role in enhancing safety performance (Zohar & Luria, 2015). Lastly, hypotheses 9 and 10 suggest that safety culture mediates the relationship between both leadership and SDUR and safety performance. Both hypotheses are supported by the analysis, with p-values of 0.000, indicating a significant relationship between the variables. The results imply that leadership, SDUR, and safety culture are crucial components in achieving optimal safety performance in the workplace.

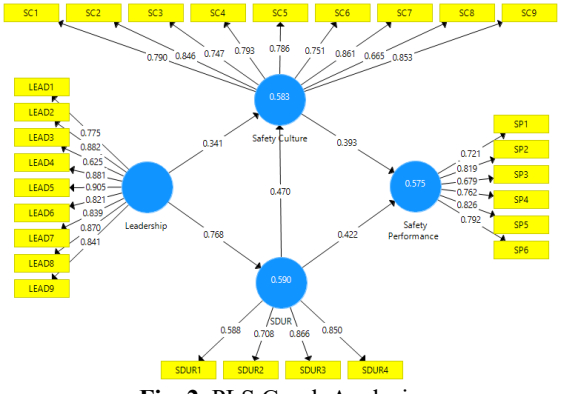

Fig. 2. PLS Graph Analysis

The findings are consistent with previous studies. Based on a study conducted by Zohar and Tenne-Gazit (2008), leadership plays a significant role in shaping safety culture in the workplace. The research found that behaviors and leadership styles that support safety are key factors in creating a positive safety culture. Additionally, the attitudes and behavior of leaders also influence the attitudes and behavior of employees towards safety in the workplace. Therefore, as a leader, it is important to pay attention to leadership practices that support safety and strengthen safety culture. This study demonstrates that appropriate leadership roles can help improve safety levels in the workplace. (Zohar & Tenne-Gazit, 2008). According to the study conducted by Wang, Guan, and Wang (2015), leadership has a significant influence on Safety Based Dynamic Uncertainty Reduction (SDUR). They found that effective leadership in managing environmental resources and making sustainable decisions is crucial to achieving SDUR. In this regard, leadership contributes to pollution control, waste management, water and energy management, as well as strengthening public participation in decision-making. Therefore, leaders committed to sustainable development principles can bring about positive and sustainable changes for the future development of cities.

Indirect analysis also showed the mediating role of safety culture referring to a safety culture employed within an organization to ensure that every activity undertaken does not jeopardize the health and safety of workers. One of the factors that influence Safety Culture Safety Based Dynamic Uncertainty Reduction (SDUR). According to Hilmola and Vaananen's (2014) research, SDUR significantly affects safety culture in the workplace. The research shows that SDUR increases the risk of accidents and hazards in the workplace. Therefore, it is necessary to take appropriate preventive measures to reduce the negative effects of SDUR on Safety Culture in the workplace. Consequently, organizational managers should consider Safety Culture as a top priority and take effective measures to mitigate the negative effects of SDUR on Safety Culture within the company.

Various studies have shown that Safety Based Dynamic Uncertainty Reduction (SDUR) has a significant influence on Safety Performance. A study conducted by Antunes et al. (2020) stated that SDUR is an important factor in improving occupational safety, as it can help obtain and analyze data related to work accidents, incidents, and unsafe working conditions. Furthermore, another study by Huang et al. (2019) showed a positive correlation between SDUR and safety behavior, where the more actively employees use SDUR, the better safety practices they implement. Therefore, SDUR can be considered as an effective strategy in improving Safety Performance in the workplace.

5. Conclusion

The results conclude that leadership has a significant effect on safety culture. It means that the way leaders lead, manage, and communicate can impact the safety practices and attitudes of their team or organization. The results also showed the significant effect of Leadership on Safety Based Dynamic Uncertainty Reduction. This showed that leadership plays a crucial role in reducing unsafe and unhealthy work environments. The results reveal significant impacts of SDUR on Safety Culture and on Safety Performance. Direct effect also showed significant effect of Safety Culture and Safety Performance. Moreover, indirect effects through mediating variables also reveal significant effects of Safety Based Dynamic Uncertainty Reduction in mediating the relationship between Leadership Safety Culture and between Leadership and Safety Performance. Safety culture was also empirically proven to have mediating effect in the relationship between Leadership and Safety Performance, and between SDUR and Safety Performance.

Theoretical implications demonstrated that Safety Based Dynamic Uncertainty Reduction was critical in aviation industry as a set of strategies and practices aimed at proactively managing safety risks in dynamic and uncertain environments. These strategies include conducting safety assessments, identifying potential hazards, implementing safety protocols and procedures, and promoting safety culture among team members. In increasing the capability of Safety Based Dynamic Uncertainty Reduction, a leader's attitude towards safety can influence their team's attitude. The findings showed that leaders who demonstrate a commitment to safety can motivate their team members to prioritize safety in their daily tasks, reducing the likelihood of accidents and injuries. Overall, leadership plays a critical role in creating a safe and healthy work environment by promoting safety culture, enforcing safety protocols and procedures, and reducing safety risks in dynamic and uncertain environments. Furthermore, practical implications of leadership and safety culture increasing in the aviation industry include promoting open communication between pilots and crew members, aircraft maintenance personnel, air traffic controllers, and all other stakeholders in the aviation industry. Effective communication can prevent miscommunication and misunderstandings that may lead to accidents.

Potential limitations obtained from the findings were related to the variables utilized in the analysis, as they may not account for all relevant or important factors that influence safety performance. For instance, other leadership styles, team dynamics, or individual employee characteristics may also play a crucial role in enhancing safety culture and improving safety outcomes. Future studies could explore these variables in more detail to provide a complete understanding of how organizational factors influence safety performance. Lastly, future studies could also explore how social and cultural factors influence safety culture and performance, such as the role of occupational norms, values, or cultural practices that shape safety attitudes and behaviors. Overall, future research should continue to explore the complex relationship between leadership, safety-based dynamic uncertainty reduction, safety culture, and safety performance, and provide actionable guidance to organizations to enhance safety outcomes.

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