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Risk Factor Assessment Causing Contract Change Orders in the Double-Double Track Project

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ABSTRACT: The Indonesian government is actively pursuing infrastructure development, with railway projects being a key focus due to their high demand in Jakarta and its surrounding regions. However, the complexity of railway projects often leads to delays and numerous changes, resulting in scope modifications that necessitate change orders, which have negative consequences for the project. Managing these risks effectively is essential to mitigate their impact on project costs and performance. This study proposes a solution through the application of risk management using a Probability Impact Matrix, which helps assess the most significant risks leading to change orders. The research aims to identify and assess the risks responsible for contract change orders in the Double-Double Track Development Project. It uses a mixed-method approach, focusing on two main phases: risk identification and risk assessment. The study examines five risk factors, including project-related factors (X1), owner-related factors (X2), contractor-related factors (X3), design-related factors (X4), and external factors (X5). The results demonstrate that all five variables significantly influence changes in project scope, with risk levels ranging from moderate to high. These findings provide valuable insights for project owners, consultants, contractors, and other stakeholders involved in construction project management. The study serves as a reference for decision-making and the implementation of control measures to minimize the negative impact of change orders

Keywords: risk assessment, contract change order, double-double track project

INTRODUCTION

The Government of the Republic of Indonesia is currently promoting infrastructure development across the country. In line with this policy, the construction industry in Indonesia has also experienced growth and expansion. This is because one of the primary drivers of economic growth is the construction sector (Khoso, Khan, Faiz, & Akhund, 2019; Mattar, Alzaim, AlAli, Alkhatib, & Beheiry, 2024).

One of the key sectors included in the national strategic projects is railway infrastructure. This is since railway transportation is one of the most popular modes of transport in Jakarta and its surrounding areas, with passenger numbers increasing year by year.

However, construction projects are inherently complex (Khoso et al., 2019; Saputra & Latief, 2020b, 2020a). Moreover, numerous factors and variables play critical roles at every stage of a construction project (Alraie, Ali Kadhum, & Shabbar, 2022). The complexity and dynamic nature of construction projects result in uncertainties and risks (Hwang & Low, 2012). Consequently, changes in the project scope may occur during the execution of construction projects.

Project scope is defined as the boundaries of a project (Rehman, ullah, Rauf, & Shahid, 2010; Tariq, Ahmad, Ashraf, Alghamdi, & Alfakeeh, 2020). It also defines what is included and excluded from the project and governs what may be added or removed during its execution (Ifeanyi, 2019). The project scope must be completed to deliver a product, service, or outcome with specified features and functions. To ensure the realization of the project scope as planned, effective project management is required.

Fig. 1: **Double-Double Track Project**

One of the ongoing national strategic railway projects is the Double-Double Track Development Project. This project is divided into two phases. For Phase 1 of the Double-Double Track Development Project (Package A), the multi-year contract was initially scheduled from 2015 to 2017. However, due to delays of approximately five years, the project was extended and completed in 2021. Meanwhile, for Phase 2 of the Double-Double Track Development Project (Package A), the contract was initially scheduled from 2019 to 2021. Nonetheless, due to the delays in Phase 1, Phase 2 was also delayed and extended until 2023.

The introduction of new scope elements has been a major issue in the Double-Double Track Development Project (Package A). Given that this project contract is a combination of unit price and lump-sum terms, where the project output and scope were predetermined at the outset, any changes may affect whether the project's outcomes align with the initial agreement.

Changes in project scope during execution should ideally be avoided and anticipated from the outset, as they can negatively impact the project (Nahod, 2012). Scope changes may lead to increased project costs and extended execution timelines (Ifeanyi, 2019). However, when scope changes are requested and additional costs are required, a change order becomes necessary. The total contract amendments for the Double-Double Track Development Project (Package A) Phase 2 are presented in Table 1.

Table 1. Total Contract Amendments in the Double-Double Track Development Project (Package A) Phase 2

No	Work Package	Total Contract Amendment	
		Total Amendment	Total CCO Amendment
1	Main Line 1	12	6
2	Main Line 2	11	5
3	Operational Facility	5	4

Change orders in construction projects are inevitable (Hwang & Low, 2012), and the project team must be prepared to address them (Suchan, 2007), as they occur frequently

(Mattar et al., 2024). A change order refers to an event that results in an increase in the original project scope, execution time, and project costs (Khoso et al., 2019). The percentage change in contract value for Phase 2 of the Double-Double Track Development Project (Package A) can be found in Table 2.

Table 2. Percentage Change in Contract Value in the Double-Double Track Development Project (Package A) Phase 2

No	Work Package	Scope Type	Change (%)
1	Main Line 1	Section 2 (Civil Works)	28.46%
		Section 3 (Track Works)	9.72%
		Section 4 (Building Works)	4.00%
		Total Change Main Line 1	**42.18%**
2	Main Line 2	Section 2 (Civil Works)	36.04%
		Section 3 (Track Works)	3.45%
		Total Change Main Line 2	**39.49%**
3	Operational Facility	Section 5 (Substation System Works)	1.77%
		Section 6 (overhead Contact System Works)	10.61%
		Section 7 (Power Distribution Line System Works)	0.25%
		Section 9 (Signalling System Works)	7.25%
		Total Change Operational Facility	**19.88%**

The impact of change orders includes meeting project needs, disputes between parties, modifications to project specifications, delays, over-budgeting, increased overhead costs, delayed payments to contractors, demolition and rework, additional payments to contractors, reduced productivity, decreased quality, and construction safety concerns (Alzara, 2022; Karthick, R, et al., 2015). Other studies have similarly indicated that the effects of change orders significantly influence cost, quality, time, and organization (Waty & Sulistio, 2022).

Although the impact of change orders is substantial, they arise from several causes. Five main factors have been identified and ranked: the project management team, consultants, contractors, and clients (Alkhalifah, Tuffaha, Al Hadidi, & Ghaithan, 2023). The root causes of change orders in hospital construction projects include contractors, owners, design, users, contractual relationships, operations, the external environment, and equipment and systems (Lavikka, Kyrö, Peltokorpi, & Särkilahti, 2019).

Other research has noted that the factors causing change orders can stem from various sources, such as owners, consultants, subcontractors, natural factors, social factors, policies, and others (Setiawan & Riantini, 2021). From the owner's perspective, the most significant causes of change orders are contractors, safety considerations, and planning and design (Waty & Sulistio, 2022). The factors leading to change order claims include human resources, materials, management, location, finances, design, documentation, force majeure, and work accidents (Utomo & Saputra, 2023).

Given these issues, it is essential to implement measures to control change orders. The application of risk management is expected to provide a solution for managing potential problems that lead to change orders, which can impact project cost performance or budgeting. One of the key stages of risk management is conducting risk analysis or assessment (Institute, 2019).

Risk assessment is an effective way to identify risks and determine the most cost-effective methods to mitigate them (Atkinson, Crawford, & Ward, 2006; Ifeanyi, 2019). The risk assessment used in this study employs the Probability Impact Matrix (PIM) or risk matrix. The probability and impact matrix is a grid for mapping the probability of each risk event and its impact on project objectives should the risk occur (PMI, 2017). This matrix identifies combinations of probability and impact that allow individual project risks to be categorized into priority groups (PMI, 2017). The use of the risk matrix in managing scope changes can be better understood when recognizing that scope change management failures always manifest as risk events.

Previous studies on risk factors causing change orders have been widely conducted. However, these studies primarily focused on identifying the risk factors without quantifying the associated risk values. Moreover, prior research has not been conducted on railway infrastructure projects. To address these gaps, this study aims to complement previous research by focusing on both risk identification and risk assessment, following the guidelines outlined in PMI (2017).

As a problem-solving approach, this study proposes the use of the Probability Impact Matrix (PIM) to assess the most significant risks contributing to change orders. This serves as a basis for formulating risk control policies through strategic measures. Therefore, the aim of this study is to identify and assess the risks causing contract change orders in the Double-Double Track Development Project.

This study has positive implications for project owners, consultants, contractors, and other stakeholders involved in construction project management. It can serve as a reference for determining appropriate change order control measures and decision-making processes. By implementing suitable control actions, strategic steps can also be developed to manage the risks causing change orders effectively.

RESEARCH METHODOLOGY

The subject of this research is the Double-Double Track Development Project (Package A) Phase 2. This project was selected as the research object because of its national scale and its inclusion as a strategic project. Additionally, it serves as an example of a project that has undergone contract change orders.

The variables examined in this study are the risk factors that cause contract change orders, which include project-related factors (X1), owner-related factors (X2), contractor-related factors (X3), design-related factors (X4), and external factors (X5). These variables will be evaluated using a closed-ended questionnaire to obtain valid responses. This research is an applied study designed with a mixed-methods approach. The mixed-methods approach integrates both quantitative and qualitative methods to address the research questions.

The study consists of two main stages: risk identification and risk assessment. The risk identification stage involves experts in validating the risk factors that cause contract change orders through a qualitative approach, asking for clear “yes” or “no” responses with a measurement scale as shown in Table 3. This is one of the tools and techniques used in risk management (PMI, 2017). The experts involved in this process include five individuals representing owners, consultants, and contractors.

Table 3. Scale for Expert Judgement

Scale	Grade	Explanation
1	Yes	These variables are risk factors that cause changes in scope
0	No	These variables and indicators are not risk factors causing changes in scope

Subsequently, 100 respondents will be involved to evaluate the influence of each variable on change orders using the measurement scale provided in Table 4. The respondents' answers will be quantitatively analyzed using descriptive statistics. The average responses will be summarized to determine the level of impact. The complete scale for risk impact levels is provided in Table 4.

Table 4. Scale of Influence Level

Scale	Grade	Explanation
1	No Influence at all	The variable has no influence at all on the scope changes
2	No Influence	The variable has no influence on the scope changes
3	Influential	The variable has an influence on the scope changes
4	Highly Influential	The variable has a significant influence on the scope changes
5	Extremely Influential	The variable has an extremely significant influence on the scope changes

The second stage involves asking respondents to conduct a risk assessment by evaluating the probability and impact of each risk factor. The risk assessment will be carried out through a questionnaire administered to 100 respondents involved in the project. The respondents' assessment results, in terms of probability and impact, will be analyzed quantitatively using descriptive statistics. The average values of probability and impact derived from the respondents' answers, based on the descriptive statistical analysis, will then be converted using the PMI Scale (2017) as presented in Tables 5 and 6. Afterward, risk analysis will be conducted by calculating the risk value, which is determined by multiplying the probability score by the impact score.

Table 5. Scale of Probability

Scale	PMI Scale (2017)	Grade	Explanation
1	0.10	Very low	Very unlikely to occur
2	0.30	Low	Unlikely to occur
3	0.50	Moderate	Somewhat likely to occur
4	0.70	High	Likely to occur
5	0.90	Very High	Very likely to occur

Table 6. Scale of Impact

Scale	PMI Scale (2017)	Grade	Explanation
1	0.05	Very low	Causes a project scope change of 0%-2.5% of the initial contract value
2	0.10	Low	Causes a project scope change of 2.5%-5% of the initial contract value
3	0.20	Moderate	Causes a project scope change of 2.5%-5% of the initial contract value
4	0.40	High	Causes a project scope change of 7.5%-10% of the initial contract value
5	0.80	Very High	Causes a project scope change of more than 10% of the initial contract value

After obtaining the risk values, the risks will be categorized based on the Probability Impact Matrix (PIM) shown in Tables 6 and 7. The final step involves ranking the risk factors from the highest to the lowest risk values to establish priorities. Although this risk assessment method is qualitative, the assessment data will be processed quantitatively.

Table 7. Probability Impact Matrix

PIM			Impact				
			Very Low	**Low**	**Moderate**	**High**	**Very High**
			0.05	**0.10**	**0.20**	**0.40**	**0.80**
Probability	**Very High**	**0.90**	0.05	0.09	0.18	0.36	0.72
	High	**0.70**	0.04	0.07	0.14	0.28	0.56
	Medium	**0.50**	0.03	0.05	0.10	0.20	0.40
	Low	**0.30**	0.02	0.03	0.06	0.12	0.24
	Very Low	**0.10**	0.01	0.01	0.02	0.04	0.08

Table 8. Risk Category

Grade	Risk Value	Colour
High	0.24 - 0.72	
Moderate	0.08 - 0.20	
Low	0.01 - 0.07	

RESULT AND DISCUSSION

Expert Profile

This study involves five experts to perform expert validation or expert judgment. The experts are stakeholders in the project, including the project owner, represented by the Directorate General of Railways, Ministry of Transportation, the supervising consultant, and the contractor. The experts hold positions such as railway inspector at the Ministry of Transportation, team leader at the supervision consultant, and project manager or deputy project manager at the contractor. These experts have over 20 years of experience in handling railway projects. Their educational backgrounds include bachelor's degrees in civil engineering and/or railway engineering, as well as master's degrees in engineering or management. A detailed profile of the experts is provided in Table 9.

Table 9. Expert Profile

Code	Project Involvement	Position	Working Experience	Education
P1	Government	Railway Inspector	25 Years	Master Degree
P2	Government	Railway Inspector	27 Years	Master Degree
P3	Supervision Consultant	Team Leader	30 Years	Master Degree
P4	Contractor	Deputy Project Manager	22 Years	Bachelor Degree
P5	Contractor	Project Manager	20 Years	Bachelor Degree

Respondent Profile

The respondent survey phase involves 100 individuals from various institutions participating in the project, including the government as the project owner, contractors, supervision consultants, and academic professionals. Their positions range from staff to managerial levels. The respondents' experience varies from 5 to 25 years, and their educational backgrounds range from diploma degrees to bachelor's and master's degrees.

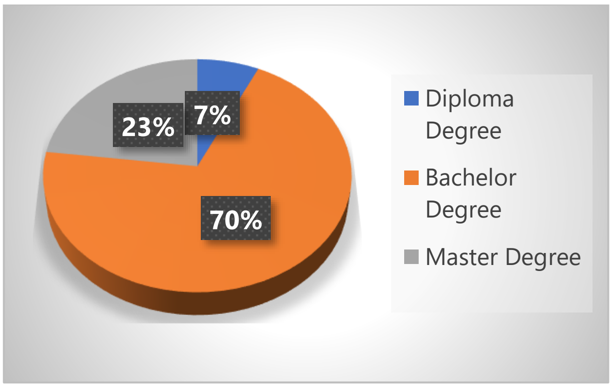

Fig. 2: **Respondent Profile Based on Education**

The summary of respondents based on their educational background is presented in Fig. 2. Respondents with a diploma degree account for 7 samples, or 7% of the total respondents. Respondents with a bachelor's degree account for 70 samples, or 70% of the total respondents. Respondents with a master's degree account for 23 samples, or 23% of the total respondents.

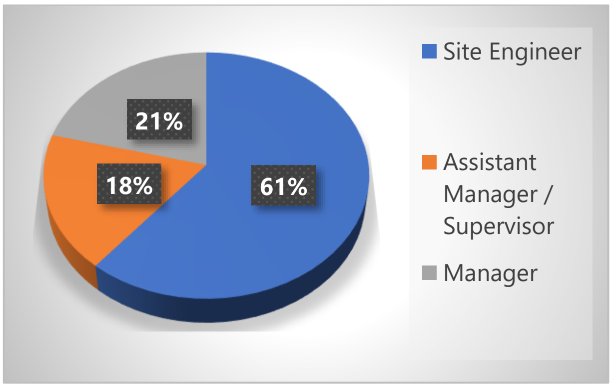

Fig. 3: **Respondent Profile Based on Position**

The summary of respondents based on their position or job title is presented in Fig. 3. Respondents at the site engineer level account for 61 samples, or 61% of the total respondents. Respondents at the assistant manager/supervisor level account for 18 samples, or 18% of the total respondents. Respondents at the manager level account for 21 samples, or 21% of the total respondents.

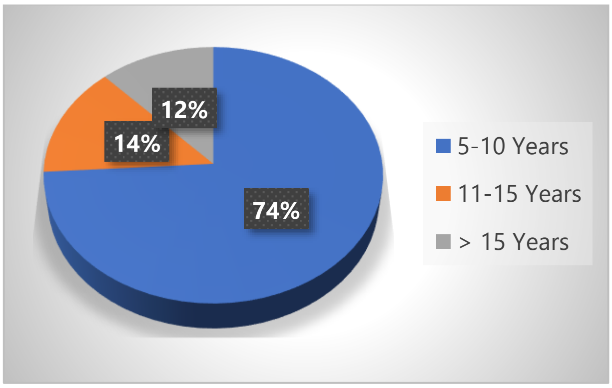

Fig. 4: **Respondent Profile Based on Experience**

The summary of respondents based on their work experience is presented in Figure 4. Respondents with 5–10 years of work experience account for 74 samples, or 74% of the total respondents. Respondents with 11–15 years of work experience account for 14 samples, or 14% of the total respondents. Respondents with more than 15 years of work experience account for 12 samples, or 12% of the total respondents.

Risk Factor

The experts mentioned above have conducted expert judgment to validate the five risk variables. The result of this expert judgment is a set of validated risk variables that will proceed to the next stage of analysis. The respondents, as previously mentioned, have also evaluated whether the variables have an impact or not. These results will be used as the basis for evaluation in the subsequent risk assessment. The outcomes of the expert judgment and respondent survey are presented in Table 10.

For Main Line 1 Work Package, 100% of the experts agreed on the risk variables. The respondents rated the influence of the project-related variable on scope changes as 5, or extremely influential. The influence of other variables on scope changes, such as owner-related, contractor-related, design-related, and external-related, was rated as 4, or highly influential.

For Main Line 2 Work Package, 100% of the experts agreed on the risk variables. The respondents rated the influence of all variables—project-related, owner-related, contractor-related, design-related, and external-related—on scope changes as 4. In other words, all variables were considered highly influential.

Similarly, for Operation Facility Work Package, 100% of the experts agreed on the risk variables. The respondents rated the influence of the project-related variable on scope changes as 5, or extremely influential. The influence of other variables on scope changes, such as owner-related, contractor-related, design-related, and external-related, was rated as 4, or highly influential.

Table 10. Expert Judgement and Responden Opinion

Code	Variable	Expert Judgement			Responden Opinion							
		Agree	Disagree	Conclusion	N	Min	Max	Mean	Me	Mo	Level	Conclusion
A. Main Line 1 Work Package												
X1	Project-Related	100%	0%	Agree	100	3	5	4.70	5	5	5	Extremely Influential
X2	Owner-Rlated	100%	0%	Agree	100	4	5	4.15	4	4	4	Highly Influential
X3	Contractor-Related	100%	0%	Agree	100	3	5	4.06	4	4	4	Highly Influential
X4	Design-Related	100%	0%	Agree	100	3	5	4.19	4	4	4	Highly Influential
X5	External-Related	100%	0%	Agree	100	3	5	4.39	4	4	4	Highly Influential
B. Main Line 2 Work Package												
X1	Project-Related	100%	0%	Agree	100	3	5	3.97	4	4	4	Highly Influential
X2	Owner-Rlated	100%	0%	Agree	100	3	5	4.00	4	4	4	Highly Influential

X3	Contractor-Related	100%	0%	Agree	100	3	5	3.72	4	4	4	Highly Influential
X4	Design-Related	100%	0%	Agree	100	1	5	3.51	3	3	3	Highly Influential
X5	External-Related	100%	0%	Agree	100	3	5	3.82	4	4	4	Highly Influential
C. Operation Facilitie WorkPackage												
X1	Project-Related	100%	0%	Agree	100	3	5	4.32	5	5	5	Extremely Influential
X2	Owner-Rlated	100%	0%	Agree	100	3	5	3.57	4	3	4	Highly Influential
X3	Contractor-Related	100%	0%	Agree	100	3	5	3.84	4	4	4	Highly Influential
X4	Design-Related	100%	0%	Agree	100	3	5	3.58	4	3	4	Highly Influential
X5	External-Related	100%	0%	Agree	100	3	5	3.80	4	4	4	Highly Influential

Risk Assessment

Probability Impact Matrix (PIM) is a risk assessment approach that evaluates risk using two criteria: Probability, which refers to the likelihood of the risk occurring, and Impact, which refers to the effect on the project if the risk materializes. This method provides a qualitative assessment of risk. The Probability Impact Matrix used for the risk assessment of scope changes in the Double-Double Track project is presented in Table 11.

In the Main Line 1 Work Package, 5 risk factor variables were successfully assessed. Project-related factors were identified as a cause of scope changes in the project, with a probability value of 0.70 and an impact value of 0.50, resulting in a risk value of 0.350. This risk factor falls into the high-risk category, ranked 2nd. Owner-related factors were the next to be analyzed, with a probability value of 0.70 and an impact value of 0.30. This factor is classified as high risk, ranked 4th. The assessment of contractor-related risks indicated a probability value of 0.70 and an impact value of 0.50, resulting in a risk value of 0.350. This factor is also considered high risk, ranked 3rd. Design-related factors were ranked 1st, with the highest risk level, having a probability of 0.70 and an impact of 0.70, leading to a risk value of 0.490. Finally, external factors were ranked 5th, also classified as high risk, with a probability value of 0.70 and an impact value of 0.35, resulting in a risk value of 0.350.

In the Main Line 2 Work Package, 5 risk factor variables were also successfully assessed. Project-related factors were ranked 2nd and classified as high risk, with a probability of 0.70 and an impact of 0.50, producing a risk value of 0.350. Owner-related factors were ranked 4th and fell into the moderate-risk category, with a probability of 0.50 and an impact of 0.30, resulting in a risk value of 0.150. Contractor-related factors were ranked 3rd, classified as high risk, with a probability of 0.70 and an impact of 0.50, leading to a risk value of 0.350. Design-related factors were ranked 1st, with a very high-risk level, having a probability of 0.70 and an impact of 0.70, resulting in a risk value of 0.490. External factors also contributed to scope changes but were classified as moderate risk, ranked 5th. The probability for this factor was 0.50, with an impact of 0.30, resulting in a risk value of 0.150.

Similarly, in the Operation Facilities Work Package, 5 risk factor variables were assessed. Project-related factors were ranked 2nd, classified as high risk, with a probability of 0.70 and an impact of 0.50, resulting in a risk value of 0.350. Owner-related factors were ranked 3rd and classified as moderate risk, with a probability of 0.50 and an impact of 0.30, producing a risk value of 0.150. Contractor-related factors were ranked 4th, also classified as moderate risk, with a probability of 0.50 and an impact of 0.30, yielding a risk value of 0.150. Design-related factors were ranked 1st, with high-risk levels, having a probability of 0.70 and an impact of 0.70, resulting in a risk value of 0.490. Lastly, external factors were ranked 5th, classified as moderate risk, with a probability of 0.50 and an impact of 0.30, producing a risk value of 0.150.

Table 11. Risk Assessment Using the Probability Impact Matrix

Code	Variable	Probability	Impact	Risk Value	Risk Category	Risk Ranking
A. Mail Line 1 Work Package						
X1	Project-Related	0.70	0.50	0.350	High	2
X2	Owner-Related	0.70	0.30	0.210	High	4
X3	Contractor-Related	0.70	0.50	0.350	High	3
X4	Design-Related	0.70	0.70	0.490	High	1
X5	External-Factor	0.70	0.50	0.350	High	5
B. Mail Line 2 Work Package						
X1	Project-Related	0.70	0.50	0.350	High	2
X2	Owner-Related	0.50	0.30	0.150	Moderate	4
X3	Contractor-Related	0.70	0.50	0.350	High	3
X4	Design-Related	0.70	0.70	0.490	High	1
X5	External-Factor	0.50	0.30	0.150	Moderate	5
C. Operation Facilities Work Package						
X1	Project-Related	0.70	0.50	0.350	High	2
X2	Owner-Related	0.50	0.30	0.150	Moderate	3
X3	Contractor-Related	0.50	0.30	0.150	Moderate	4
X4	Design-Related	0.70	0.70	0.490	High	1
X5	External-Factor	0.50	0.30	0.150	Moderate	5

CONCLUSION

Based on the data analysis and discussion, it can be concluded that variables related to the project, owner, contractor, design, and external factors are significant risk factors influencing scope changes in the Double-Double Track development project. The priority risks vary by work package: in the Main Line 1 Work Package, the top risks are design-related, followed by project-related, contractor-related, external factor-related, and owner-related risks; in the Main Line 2 Work Package, the priority order is design-related, project-related, contractor-related, owner-related, and external factor-related; while in the Operation Facility Work Package, the sequence is design-related, project-related, owner-related, contractor-related, and external factor-related. Although the findings cannot be generalized to all projects due to the unique characteristics of each project, this research provides a valuable reference for risk management in addressing scope changes. Identifying priority risks allows for the formulation of preventive and corrective control measures, as well as tailored strategies to manage these risks effectively.

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