# Risk Impact Analysis Using House of Risk Method and Probability Impact Matrix in Double-Double Track (DDT) Project PT. Hutama Karya

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**Abstract.** Probability Impact Matrix and House of Risk have been the ultimate framework for indentifying potential and critical hazards, also prioritizing risks in infrastructure projects. PT. Hutama Karya, bonafide state owned company, underwent prestigious Double-Double Track Project. It potentially encountered failures due to various riks on the field. The objective of this study is to identify risk factors and prioritize risk impacts by using House of Risk Method and risk mapping by using Probability Impact Matrix. Datas were gathered through interviews and questionnaires. From the risk agent it was found that the level of risk value measures as many as 4 high-value risk agents through the Probability Impact Matrix. Furthermore, in the Phase 2 House of Risk in risk management strategy, 12 actions were taken to handle the overall risk agents in the Double-Double Track (DDT) project.
**Keywords**: House of Risk, Risk Identification, Risk Mapping, Probability Impact Matrix, Double Track Infrastructure Project

## 1. INTRODUCTION

One of the most dangerous sectors is infrastructure project [1,2]. Therefore, companies that worked on infrastructure field must take careful precaution related to possible hazard or risk [3,4]. In the last decade, infrastructure projects had been rising to 48,7% spreaded in many sectors. Particularly, transportation infrastructure took the biggest portion (23,8%) in infrastructure development [5,6]. PT Hutama Karya is one of big state-owned companies in Indonesia, and has been running many crucial infrastructure projects. The ultimate project is Double-Double Track Project, like the other prime infrastructure project, that predicted to bring regional economic growth to 37% [7]. There are high possibilities that DDT will encounter various risks which can be mitigated or avoided [7]. Moreover, thorough risk assessment is needed.

Risk assessment aimed to mitigate or avoid risk and even reduce risk [3,5]. Meanwhile risk management framed as qualitatives and quantitatives analysis techniques to define risk handling strategy [4,8,9]. Hazard identification process is one of significant process in final subphase of risk analysis management, and it is considered as total process of risk management [2,6]. The objective of hazard identification is for mapping all possible hazards that will occur [1]. In risk management, House of Risk often utilized alone rather than assimilated with Probability Impact Matrix [10,11]

Therefore, the purpose of this study is to design risk mitigation strategy by using probability impact matrix and house of risk. This study consists of four sections. A theoretical background is presented in

section 1. House of Risk and Probability Impact Matrix as methods are described in section 2. Moreover, data analysis and conclusion are discussed in section 3 and 4 sequentially.

## 2. METHODS

This study implemented both qualitative and quantitative datas. Qualitative datas were gathered through interviews with several experts in Logistic Division, previously questionnaires were filled by workers who worked in the procurement of DDT Project. Quantitative method was made through risk severity, probability, and impact questionnaires. In phase 1, risk events measured with Likert Scale (1=loss can be ignored; to 5=very high loss). Moreover, Likert Scale was also applied in measuring severity/impact (1=impacts can be ignored; to 5=severe impacts) and occurance/probability (1=almost never occurred; to 5=always occurred) of risk agents. Questionnaires items were adopted from several previous researches [2,3,6]

There are six steps in data processing. First, brainstorming was attended by few workers in Logistic Division to define important risk events and risk agents. Then, risk events and agents questionnaires were made to measure impacts and probability consecutively. Third, ranking of each risk agents was calculated using House of Risk (phase 1). The following step would be measuring Probability Impact Matrix of each risk agents. Finally, this study defined risk mitigation strategy using House of Risk (phase 2)

## 3. RESULT AND DISCUSSION

### *3.1 Defining Risk Agents Priority Using House of Risk (HOR) Phase 1*

House of Risk in the first phase aims to define risk priority based on Aggregate Risk Priority (ARP) that generates from Occurance (O) of risk agents, Severity (S) of risk event, and Correlation (R) value berween risk agents and events. 3 respondents who work in Logistics and Equipments (Procurement Division) are involved in answering the questionnaires of Risk Event Severity. Below is Table 1.Risk Severity Scale

**Table 1.** Risk Severity Scale

| Index | Score | Description |
|---|---|---|
| **Very High** | 5 | Very High Loss |
| **High** | 4 | High Loss |
| **Mid** | 3 | Average Loss |
| **Low** | 2 | Low Loss |
| **Very Low** | 1 | Loss can be ignored |

Severity results is drawn from highest severity score. Table 2. Severity Scoring can be shown in table 3. After calculating severity scale, respondents will have to score probability/occurance of risk agents. This step is the predecessor of defining Probability Impact Matrix (PI-M).

**Table 2.** Scoring Risk Event Scale in *procurement* project of DDT Manggarai - Jatinegara

| Risk Events (Code) | Respondent 1 | Respondent 2 | Respondent 3 |
|---|---|---|---|
| **Insufficient materials or no available materials (RE1)** | 5 | 4 | 4 |
| **Materials and equipment already have not good quality (RE2)** | 3 | 2 | 2 |
| **Differences between material specifications in storage and field design specifications (RE3)** | 3 | 3 | 3 |
| **Occurance of materials overstock in the warehouse (RE4)** | 2 | 2 | 1 |
| **Suspended Supplier (RE5)** | 3 | 2 | 3 |
| ***Force Majeure* (RE6)** | 3 | 3 | 2 |

**Table 3**. Probability Index Scale (Converted *occurance scale)*

| Index | Score | Score | Description |
|---|---|---|---|
| **Very High** | 5 | 0.9 | Always occur |
| **Tinggi High** | 4 | 0.7 | Often occur |
| **Mid** | 3 | 0.5 | Usually occur |
| **Low** | 2 | 0.3 | Rarely occur |
| **Very Low** | 1 | 0.1 | Very rareky occur |

Table 4 below shows the result of probability scoring of risk agents in procurement project DDT Manggarai-Jakarta.

**Table 4.** Scoring probability/occurance of risk agents in *procurement* project DDT Manggarai – Jatinegara

| Code | Risk Agent | Respondent I | Respondent II | Respondent III |
|---|---|---|---|---|
| **A1** | Rare material procurement | 0.5 | 0.3 | 0.5 |
| **A2** | Supplier performance is not good or optimal | 0.7 | 0.7 | 0.5 |
| **A3** | Long distance expedition | 0.5 | 0.5 | 0.3 |
| **A4** | Received materials are not conform with specification | 0.7 | 0.5 | 0.5 |
| **A5** | Mistakes in calculating estimated volume | 0.5 | 0.5 | 0.5 |
| **A6** | Mistakes of calculating estimated budget of procurements | 0.7 | 0.7 | 0.5 |
| **A7** | Miss-communication during coordination amongst staffs | 0.3 | 0.5 | 0.3 |
| **A8** | Leadtime of defining material needs from the field workers | 0.1 | 0.3 | 0.3 |
| **A9** | Storage space insufficient or limited | 0.5 | 0.5 | 0.5 |
| **A10** | Work accidents occurance | 0.1 | 0.1 | 0.1 |
| **A11** | Minimum maintenance of materials and equipments | 0.5 | 0.3 | 0.5 |
| **A12** | Design change orders that affect to materials requirement change | 0.5 | 0.3 | 0.3 |
| **A13** | Queueing in Materials management is suboptimal | 0.1 | 01 | 0.1 |
| **A14** | Suspended Supplier that can not fulfill requirements due to currency inflation | 0.1 | 0.1 | 0.1 |
| **A15** | Extreme weather that affects material quality | 0.1 | 0.1 | 0.1 |

After defining the probability/occurance of risk agents, the following steps will be calculating Probability Impact Matrix (PI-M). Questionnaire scale of procurement risk agents can be shown in table 5. Moreover, result of risk agents impact/severity describes in table 6.

**Table 5.** Impact/Severity *Scale*

| Index | Score | Score | Description |
|---|---|---|---|
| Very High | 0.8 | 5 | Very High Loss |
| High | 0.4 | 4 | High Loss |
| Mid | 0.2 | 3 | Average Loss |
| Low | 0.1 | 2 | Low Loss |
| Very Low | 0.05 | 1 | Loss can be ignored |

**Table 6** Impact/Severity Scoring and Importance Rating of Procurement Risk Agents DDT Project Manggarai – Jatinegara

| | | Impact/Severity Scoring | | | Importance Rating | | |
|---|---|---|---|---|---|---|---|
| **Code** | **Risk Agent** | **Respondent I** | **Respondent II** | **Respondent III** | **Respondent I** | **Respondent II** | **Respondent III** |
| **A1** | Rare material procurement | 0.8 | 0.4 | 0.8 | 0.5 | 0.8 | 0.40 |
| **A2** | Supplier performance is not good or optimal | 0.8 | 0.8 | 0.4 | 0.7 | 0.8 | 0.56 |
| **A3** | Long distance expedition | 0.4 | 0.2 | 0.2 | 0.5 | 0.4 | 0.20 |
| **A4** | Received materials are not conform with specification | 0.4 | 0.2 | 0.4 | 0.7 | 0.4 | 0.28 |
| **A5** | Mistakes in calculating estimated volume | 0.4 | 0.4 | 0.4 | 0.5 | 0.4 | 0.20 |
| **A6** | Mistakes of calculating estimated budget of procurements | 0.2 | 0.4 | 0.1 | 0.7 | 0.4 | 0.28 |
| **A7** | Miss-communication during coordination amongst staffs | 0.1 | 0.05 | 0.2 | 0.3 | 0.2 | 0.06 |
| **A8** | Leadtime of defining material needs from the field workers | 0.4 | 0.2 | 0.4 | 0.3 | 0.4 | 0.12 |
| **A9** | Storage space insufficient or limited | 0.1 | 0.2 | 0.2 | 0.5 | 0.2 | 0.10 |
| **A10** | Work accidents occurance | 0.8 | 0.8 | 0.4 | 0.1 | 0.8 | 0.08 |
| **A11** | Minimum maintenance of materials and equipments | 0.2 | 0.1 | 0.2 | 0.5 | 0.2 | 0.10 |
| **A12** | Design change orders that affect to materials requirement change | 0.4 | 0.4 | 0.4 | 0.5 | 0.4 | 0.20 |
| **A13** | Queueing in Materials management is suboptimal | 0.05 | 0.05 | 0.05 | 0.1 | 0.05 | 0.01 |
| **A14** | Suspended Supplier that can not fulfill requirements due to currency inflation | 0.1 | 0.05 | 0.05 | 0.1 | 0.1 | 0.01 |
| **A15** | Extreme weather that affects material quality | 0.4 | 0.4 | 0.2 | 0.1 | 0.4 | 0.04 |

Based on calculation of risk events severity and risk agents occurance, the next process will be defining risk priority based on ARP value in House of Risk Phase 1 (HOR 1). The result can be shown in picture below

| | RISK AGENT | | | | | | | | | | | | | | | SEVERITY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RISK EVENT | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 | |
| RE1 | 9 | 9 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | | 3 | 3 | | 1 | 3 | 5 |
| RE2 | | | | | | | 1 | | 9 | 3 | 9 | | 1 | | | 3 |
| RE3 | | | | | | | | | | | | 9 | | | | 3 |
| RE4 | | | | | | | | | | | | | 3 | | | 2 |
| RE5 | | | | | | | | | | | | | | 3 | | 3 |
| RE6 | | | | | | | | | | | | | | | 3 | 3 |
| OCCURANCE | 3 | 4 | 3 | 4 | 3 | 4 | 2 | 2 | 3 | 1 | 3 | 3 | 1 | 1 | 1 | |
| ARP | 135 | 180 | 45 | 60 | 45 | 60 | 16 | 10 | 96 | 9 | 126 | 126 | 9 | 14 | 24 | |
| PERINGKAT | 2 | 1 | 8 | 6 | 9 | 7 | 11 | 13 | 5 | 14 | 4 | 3 | 15 | 12 | 10 | |

**Figure 1.** *House of Risk* (HOR1)

From HOR 1, it describes that risk priority was drawn from ARP Rank of each risk agents, as served in the table 7 below.

**Table 7.** Risk Agents Rankings

| Rank | Risk Agents | ARP | Rank | Risk Agents | ARP |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 1 | A2 | 180 | 9 | A5 | 45 |
| 2 | A1 | 135 | 10 | A15 | 24 |
| 3 | A12 | 126 | 11 | A7 | 16 |
| 4 | A11 | 126 | 12 | A14 | 12 |
| 5 | A9 | 96 | 13 | A8 | 10 |
| 6 | A4 | 60 | 14 | A10 | 9 |
| 7 | A6 | 60 | 15 | A13 | 9 |
| 8 | A3 | 45 | | | |

*3.2 Defining Risk Importance Using Probability Impact Matrix (PI-M) for Each Risk Agents*

After ranking ARP, this study defines risk mapping using Probability Impact Matrix (PI-M) as shown in the picture 2. Risk mapping aims to figure out risk importance level. Risk importance results from mulitplying of risk probability score and impact score. Score scale is described in the table 6.

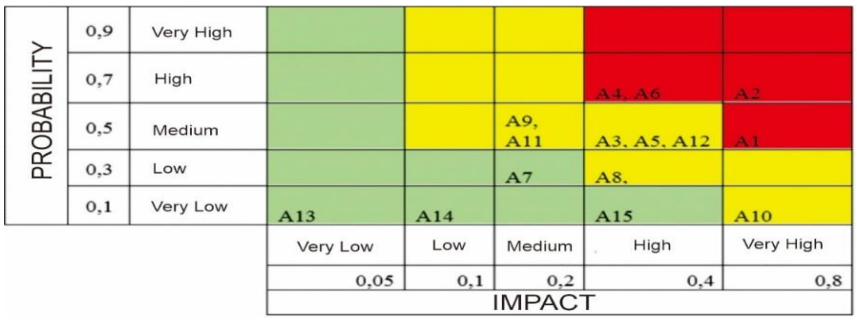


**Figure 2.** Procurement Risk Matrix DDT Manggarai Project– Jatinegara

The next step will be risk mapping from aggregating risk probability, impact, and importance. Each risk agents are mapped in risk matrix as shown in the picture 2. Red matrix shows that risk agents are considered as high risk. Moreover, yellow areas correlate to medium risk and green areas correlate to low risk.

*3.3 Defining Priority of Risk Handling Strategy with House of Risk (HOR) Phase* 2

House of Risk (HOR) phase 2 aims to define risk response based on House of Risk 1 (HOR 1). Respondents are still the same as previous phase. Results can be seen in table 8 belows:

**Table 8.** Risk Handling Strategy in *procurement Double-Double Track*

| Code | Risk Handling Strategy |
|---|---|
| **PA1** | Make alternatives of joint supplier, just in case of the force majeur so that material procurement still can be ordered. |
| **PA2** | Well-planned and proper site survey also exact implementation |
| **PA3** | Training and dissemination of warehouse management to logistics and equipment division |
| **PA4** | Choosing supplier and its quality selectively |
| **PA5** | Penalty punishment to suppliers that misconduct the contract or send bad quality materials |
| **PA6** | Enhancing planning management policy to be more strategic and accurately implement |
| **PA7** | Allocate budget of redundant materials to materials that still need more budget |
| **PA8** | Scheduling supplier procurement and arrival time of materials precisely |
| **PA9** | Designing warehouse layout that can minize the effect of extreme weather |
| **PA10** | More coordination between divisions and disseminate teamwork throughout workers in return to enhance communication qualities |
| **PA11** | Enhancing contract management quality especially between company and supplier |
| **PA12** | Conduct training of work safety and assist working permits |

There are 12 risk handling strategies of procurement risk in Double-Double Track Project Manggarai-Jatinegara as shown in Table 9, whether to generate HOR2 this study needs value of complexity degree.

**Table 9.** Degree of Complexity of Risk Handling in *procurement Double-Double Track* Manggarai – Jatinegara

| Risk Handling Strategy | Degree of complexity | Risk Handling Strategy | Degree of complexity |
|---|---|---|---|
| PA1 | 3 | PA7 | 4 |
| PA2 | 5 | PA8 | 4 |
| PA3 | 3 | PA9 | 5 |
| PA4 | 4 | PA10 | 3 |
| PA5 | 3 | PA11 | 4 |
| PA6 | 5 | PA12 | 3 |

With the assessment of the degree of difficulty of each procurement risk management strategy for the Manggarai - Jatinegara Double-Double Track project, the implementation of House of Risk (HOR) phase 2 can be carried out, where the second stage of the House of Risk (HOR) aims to find out how effective risk management strategies that are applied by taking into account the value of Total Effectiveness (TEk), the relationship between correlation (Ejk) between the relationship of strategy and risk agent and the Aggregate Risk Priority (ARP) value of each risk agent, then the discovery of the Effectiveness to Difficulty (ETD) value is obtained from the results of TEk divided by the Degree of Difficulty (Dk) or degree of difficulty, so that the final results of the ranking of risk management strategies are found in terms of ETD values. Below is the result of HOR 2:

| | RISK HANDLING STRATEGY | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RISK AGENT | PA1 | PA2 | PA3 | PA4 | PA5 | PA6 | PA7 | PA8 | PA9 | PA10 | PA11 | PA12 | ARP |
| A2 | 9 | | | 9 | | | | | | | | | 180 |
| A1 | 9 | | | | | | | 3 | | | | | 135 |
| A12 | | 9 | | | | | | | | | | | 126 |
| A11 | | | 9 | | | | | | | | | | 126 |
| A9 | | | 3 | | | | | | | | | | 96 |
| A4 | | | | 3 | 9 | | | | | | | | 60 |
| A6 | | | | | | 9 | 3 | | | | | | 60 |
| A3 | 3 | | | 1 | | | | 9 | | | | | 45 |
| A5 | | | | | | 9 | | | | | | | 45 |
| A15 | | | | | | | | | 9 | | | | 24 |
| A7 | | | | | | | | | | 9 | | | 16 |
| A14 | | | | | | | | | | | 9 | | 12 |
| A8 | | | | | | | | | | 3 | | | 10 |
| A10 | | | | | | | | | | | | 9 | 9 |
| A13 | | | 3 | | | | | | | | | | 9 |
| Tek | 2970 | 1134 | 1449 | 1845 | 540 | 945 | 180 | 810 | 216 | 174 | 108 | 81 | |
| Dk | 3 | 5 | 3 | 4 | 3 | 5 | 4 | 4 | 5 | 3 | 4 | 3 | |
| ETD | 990 | 227 | 483 | 461 | 180 | 189 | 45 | 203 | 43 | 58 | 27 | 27 | |
| RANK | 1 | 4 | 2 | 3 | 7 | 6 | 9 | 5 | 10 | 8 | 11 | 12 | |

**Picture 3.** *House Of Risk* (HOR) Phase 2 Procurement Risk Handling Strategy in DDT Manggarai – Jatinegara Project

From the second stage of the House of Risk (HOR) calculation, a sequence of risk management strategies is obtained based on the highest ETD calculation results. Where the implementation of risk management strategies is known priority based on the rank obtained so that it is expected to be able to overcome procurement risks in the Manggarai - Jatinegara DDT project which can be seen from table 10.

**Table 10.** Procurement Risk Mitigation Strategy of DDT Manggarai – Jatinegara Project

| Rank | Risk Handling Strategy | Rank | Risk Handling Strategy |
|---|---|---|---|
| **1** | PA1 | 7 | PA5 |
| **2** | PA3 | 8 | PA10 |
| **3** | PA4 | 9 | PA7 |
| **4** | PA2 | 10 | PA9 |
| **5** | PA8 | 11 | PA11 |
| **6** | PA6 | 12 | PA12 |

Based on the table above, it is obtained that the priority handling strategy to be applied based on the highest ETD calculation result is PA1 handling strategy, which has an alternative backup partner supplier so that the material needed can be carried out by the procurement process then continued with PA3 namely the handling strategy in the form of providing training and socialization of the warehouse.

## 4. CONCLUSION

The risk agent that has the highest to the lowest ranking priority is the supplier's poor performance (A2) with ARP 180, then the procurement of scarce material (A1) ARP 135, then there is a change in project implementation design that changes the material specification requirements (A12) ARP 126, then lack of care for materials and equipment (A11) ARP 126, hereinafter is inadequate or limited storage area (A9) ARP 96, material received is not in accordance with ARP 60 (A4) specifications, then Error in calculating the estimated budget procurement costs with an ARP value of 60, then with an ARP value of both 45 are occupied by risk agents for long distance travel (A3) and an error in calculating material volume estimates (A5), then aagen risk of extreme weather events affecting the material with a value ARP 24, then lack of coordination between employees (A7) ARP 16, contractual relations with non-permanent partners both due to changes in the exchange rate of the rupiah (A14) ARP by 12, then still awaiting the certainty of material needs from the executor (A8) ARP 10, and the occurrence of work accidents (A10) and management of material inventory queues that have not been good (A13) with the acquisition of value ARP both are 9.

There are several risk agents that occupy a high, medium, and low risk level in the Probability Impact Matrix (PI-M), namely A2, A1, A6 and A4, which are in the red position, that means the size of the risk level is high, then A3, A5, A12, A8, A9, A11 and A10 are in the yellow position which means that the measurement of the level of risk is medium, and the last is A7, A15, A14 and A13 are in the green position which means that the measure of the risk level is of low value.

From the several handling strategies obtained, it is found that the priority ranking for risk management strategies was applied more priority, namely having alternative backup partner suppliers so that the material needed could be carried out by the procurement process (PA1) with an ETD value of 990, then providing training and socialization of the warehouse. management to logistics & equipment (PA3) with ETD of 483, then tightening the quality of supplier selection (selective) (PA4) with ETD of 461, then planning a more thorough and precise design implementation survey (PA2) with ETD of 227 and scheduling processes procurement of goods with an estimated time of delivery of the material delivery by the supplier (PA8) with ETD of 203, and so on.

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