# TRAIN DERAILMENTS IN INDONESIA - A STUDY USING HUMAN FACTORS ANALYSIS AND CLASSIFICATION SYSTEM

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***ABSTRACT***

*Train derailments rank highest among train incidents in Indonesia. The financial burdens caused are typically great. It is, thus, necessary to investigate factors contributing to the accidents, as an effort to minimize the problem. This study employed HFACS-RR (Human Factors Analysis and Classification System – for Railroad). 185 derailments in all Operational Regions (DaOp) in Java for the past 10 years were classified into levels of HFACS-RR to know what factors are contributing causes derailment, especially in relation to human factors. The results showed that human factors had a significant contribution to the cause of the derailment incidents. Although half was dominated by technological factors/technical, there were also considerable factors such as the contribution of human supervision (supervisory, rule making (organizational) and social behavioral factors of train consumer (outside).*

***Key words** : Derailments, HFACS-RR, Railroad incidents, safety, human error*

## 1. INTRODUCTION

Railway transportation has several advantages. As mentioned in Law 13 of 1992, "*Railway is one of the modes that have special characteristics and advantages, especially in its ability to transport both passengers and goods in bulk, saving energy, saving in the use of space, has a high safety factor, and the level of low pollution and more efficient compared with other modes of transport by road for long distances and for heavy traffic areas, such as public transportation*."

But this mode of transportation is still associated with various problems, such as safety. Based on data from the Directorate General of Railways in the period 2004-2010, 706 train incidents/accidents occurred, including three types of accidents - collisions between trains (36 events or 5.11%), 139 incidence of collisions between trains and other motor vehicles (19.68 %), derailments and rolled over trains (531 events or 75.21%). This event caused a great number of victims. According to government report, 367 people died (54%), 654 people were seriously injured (40.17%), and 607 people had minor injuries (37.29%) (Strategic Plan 2010-2014 Ministry of Transportation, the railways).

One type of train incidents that often occurs is derailments, which is an event in which train wheels dislodged from the tracks. Passenger train accidents or train derailments/rolled over dominated every rail accident in 10 years (MTI, 2006). Recent data from PT. KAI, during the year 2012 (January-September) there has been 39 derailment cases. This figure has not been added to the events occurred in October-November which was five cases. Although the number of casualties has not been significant so far, but it has the potential to become a fatal accident. Train accidents can cause substantial financial loss, due to infrastructure damage and operating losses associated with road blocks. For example, in the case of accidents KA three times tumbled in South Sumatra in the months of February-April 2006 resulted in estimated losses of about Rp. 3 Billion or any accidents cause an average loss of one billion rupiah (NTSC).

PT. KAI in a recent presentation on safety indicated statistics of the accidents as illustrated in the following diagram:

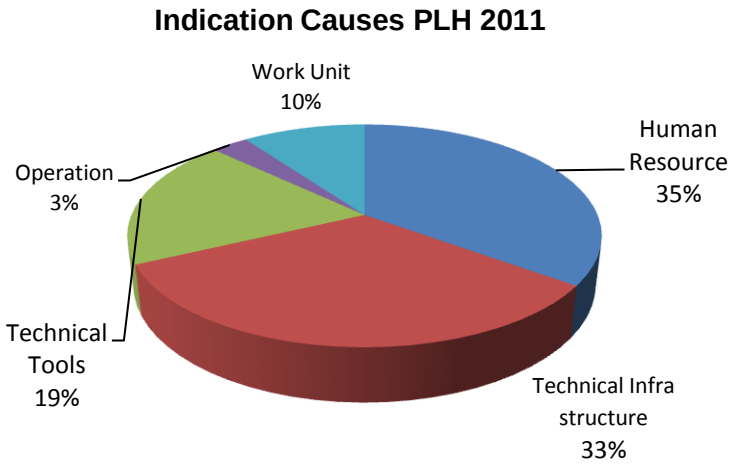


Figure 1. Accident causes for 2011 (PT. KAI, 2012)

There is an indication that the cause of a train accident is generally dominated by the factor of human resources (as much as 35%). It motivates this research to focus on human factors, namely by using HFACS. The selection is based on the HFACS method usefulness in data collection and analysis. HFACS has been considered a tool that is able to diagnose accidents reliably and comprehensively (Shappel and Wiegmann, 2003). HFACS method has been successfully used in other domains such as Air Traffic Control (Scarborough and Pounds, 2001) and in military operations (in Wiegmann and Shappel, 2003), and can be applied in the railroad industry because of the general terms it employs.

This research was aimed at analyzing the factors that cause and contribute value in the case of railway accidents in Indonesia using a structured method called HFACS (Human Factor Analysis and Classification). Objects of the study was limited to nine operational regions in Java.

## 2. RESEARCH METHOD

### 2.1 HFACS – RR

One advantage of this HFACS method is its form that is general, and descriptors that can be applied in a variety of activities and industries. HFACS was originally used in the development of the aviation industry. It had minor changes to optimize the level of relevance in the railway industry. HFACS taxonomy changes into HFACS-RR, and includes (Reinach and Vialle, 2006):

- Changing the "violations" to "contraventions"
- Addition of subcategories under the "contraventions" that "acts of sabotage"
- Addition of subcategories under organizational factors, namely "organizational contravention".

### 2.2 Procedure

Data collection was carried out in stages. The first set of data were obtained from the National Transportation Safety Committee (KNKT), while the second set was from Railway Directorate General, the Ministry of Transportation, and other data from media such as newspapers, internet, and television. These three data sources were combined to recapitulate and further classified into HFACS taxonomy to determine the factors that contribute to the cause of the incident, then we conducted a qualitative descriptive analysis approach based on the data collected.

## 3. RESULTS

In this study, data were collected sourced from NTSC investigation report, data summary from the Department of Transportation and the Environmental Management media (newspapers, internet, and TV). The data include all events falling in the past 10 years, from the year 2003-2012. Statistically, event data are presented in several tables shown below.

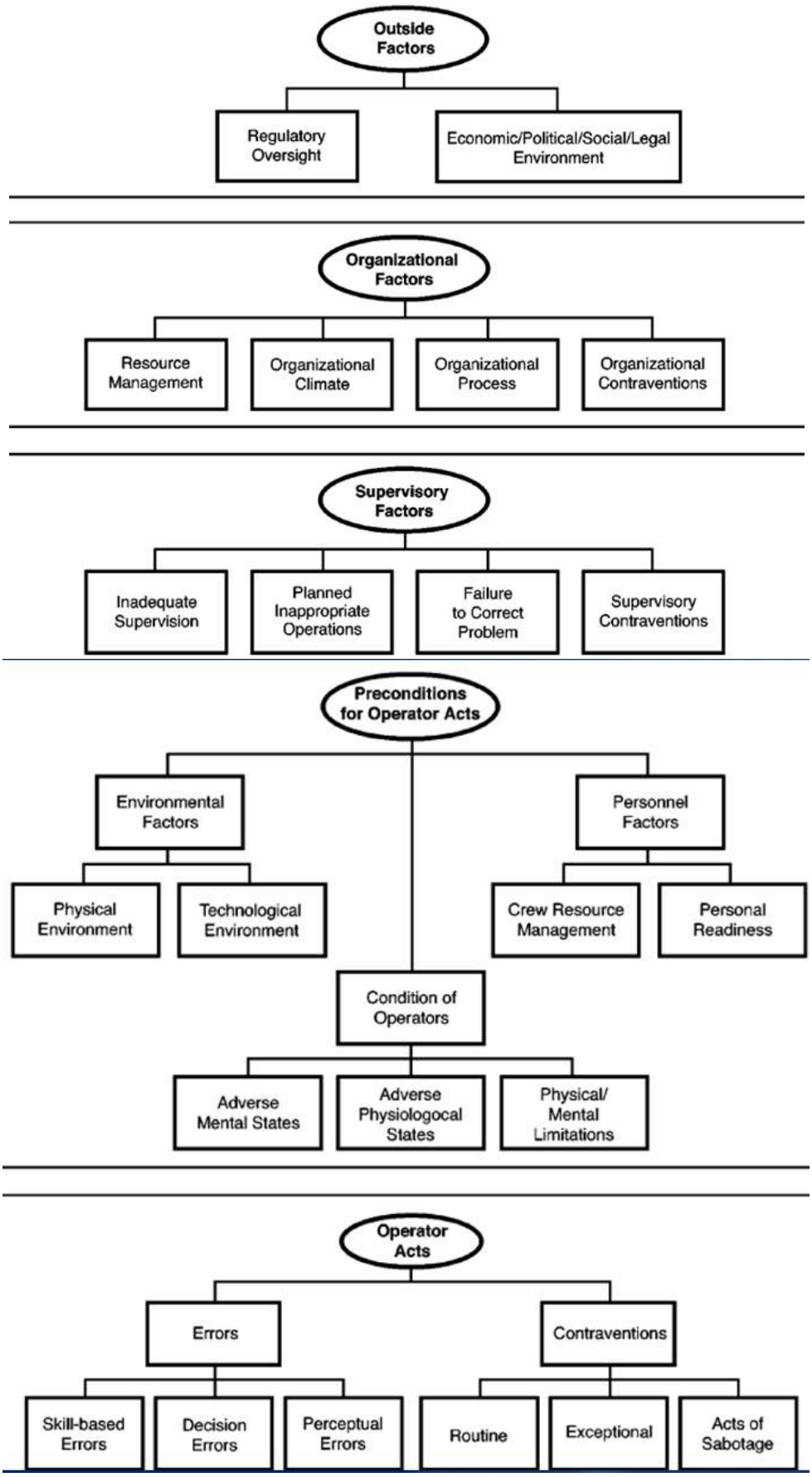


Figure 2. HFACS-RR Taxonomy

Table 1. Statistical data on derailments obtained from NTSC,

Ministry of Communications and Media

| Year | 2003-2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|---|---|---|---|---|---|---|---|---|
| Number of accidents | 12 | 111 | 106 | 44 | 29 | 27 | 12 | 341 |

Table 2. Data Case derailment of Daop in Java that can be analyzed using HFACS

| | Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DaOp (Operational Region) | 2003 | 2004 | 2005 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total | Rank |
| 1 | 1 | - | - | 6 | 10 | 8 | 7 | 4 | 2 | 38 | 1 |
| 2 | - | 1 | - | 9 | 8 | 2 | 4 | 3 | - | 27 | 3 |
| 3 | 2 | - | - | 5 | 3 | 2 | 3 | - | 1 | 16 | 6 |
| 4 | 1 | - | - | 4 | 6 | 9 | 3 | 2 | 1 | 26 | 4 |
| 5 | - | 1 | 1 | 9 | 5 | 3 | - | 1 | - | 20 | 5 |
| 6 | - | - | - | 4 | 1 | 1 | 1 | - | 1 | 8 | 8 |
| 7 | 2 | 1 | | 2 | 2 | 3 | 2 | 1 | | 13 | 7 |
| 8 | - | - | - | 8 | 9 | 5 | 3 | 3 | 1 | 29 | 2 |
| 9 | - | - | - | - | 1 | 1 | 3 | 3 | - | 8 | 9 |
| | 6 | 3 | 1 | 47 | 45 | 34 | 26 | 17 | 6 | 185 | |

Thus, the amount of data that can be analyzed using HFACS is as follows □ (185/341 x100% = **54.25%)** of 341 total crash data that had been obtained. A total of 185 (54,25%) which can be analyzed using HFACS. This is because the data are known to cause only a factor of 185 pieces. From nine Daop that were the objects of study, the data then were sorted according to incident frequency. Daop 1 (Jakarta) ranked first, followed by Daop 2 (Bandung) and Daop 8 (Surabaya). The results of the classification and taxonomy that shows the contribution of each causes of the crash of HFACS level using HFACS-RR, are presented in Table 3.

Table 3. Contributing causes for derailment at every level of HFACS

| Level | Contribution |
|---|---|
| **Operator Acts** | **29,3 %** |
| **Preconditions for Operator Acts** | **51,6 %** |
| **Supervisory Factors** | **8,1 %** |
| **Organizational Factors** | **9,8 %** |
| **Outside Factors** | **1,6 %** |

The results presented in Table 3 show that 51.6% of all factors contributing to the incidents were grouped into preconditions for operator acts. For this level, there were thre sub-levels and seven categories of causal factors that contribute to each event. Next was operator acts at the level of 29.3% which has two sublevel with six categories, organizational factors of 9.8% with four categories, supervisory factors 8.1% who also had four categories and the last outside factors of 1.6% with two categories. Existing data were classified according to the 23 categories available in each weighs upon each level HFACS taxonomy.

## 4. DISCUSSION

Based on the data obtained, half of the factors of the derailment incidents were caused by preconditions for operator acts. This level indicates several conditions that affect the operator directly. The dominance of the cause is the sub level environmental factors, which has two categories: the physical environment and technological environment. Things that include physical work environment factors is like the weather, heat, light, and vibration. Technology is associated with factors such as equipment

design, layout, interface and the use of automation.

In cases that were categorized almost entirely into technological factors / technical, some of the main causes are the conditions of facilities and infrastructure. Conditions facilities include damage to axles and wheels (as a broken, hollow wheels, bearing loss), braking that does not work properly, uneven loading, overloading, lack of maintenance means, and the use of non standard parts. Meanwhile, the conditions of the infrastructure include rail road is not good (bearing wood brittle, broken rails, rail cracks, a former rail storage that is too close to the main railway, damaged notes, collapse/vanished roads, less ballast or not by default), deficient bridges (lack of maintenance, the rust on the iron bridge), and problems due to mud pumping.

Then, over a quarter of other causes were in the level of the operator acts. In this case, the operator in question is the main driver in control for the train. The main mistakes made by the driver is a violation of the posted speed limit. Besides the driver, other mistakes that can be made are the officers notes which is sometimes incorrectly perceived. Level one and two in the HFACS taxonomy indeed are the dominant factors contributing to the derailments. Taken together they reach 80% to the overall contributions. But after analysis, levels 1 and 2 is also caused also by three levels above (the supervisory factors, organizational factors, and outside factors).

Supervisory factors (control factors) in this case is closely related to the state of infrastructure. Control officer is less detail in performing examinations, and may make the condition of facilities and infrastructure to be less monitored.

Organizational factors (organizational factors) also contribute to the cause of the derailments. One is related to the scheduling of work hours that are not done appropriately, which can cause physical fatigue to the operator. Another issue is the schedule of inspection facilities or infrastructure produced by organizations that do not fit. This caused the checking procedure that does not evaluate all circumstances. Availability of the tools / support facility operator (communication radio or other communication tools) are already inadequate or obsolete.

In terms of human resource deployment, allocation of human resources and train maintenance facilities other than technical human resource was less than 17%. The low number of recruitment of competent railway vehicle maintenance and other technical operators were unsatisfactory compared to the number of facilities that need to be maintained and repaired (Purwoko, 2008). Levels of the organization is also closely related to the financing terms for all needs associated with train operations. Lack of funding may lead to the sustainability of operations to be less than what is expected.

Finally, there is the level of outside factors. This is one that relates to the condition of society and social behavior. For the derailment case, which is directly related to environmental factors such as theft and vandalism committed by local people in the surrounding community. Vandalism includes stealing the joint bolts that fasten the rail and rail cutting. Such behavior is certainly a potential cause to infrastructure damage that subsequently contributes directly to the accidents. Decisive action of the elements of the organization and the government is required to follow up and to control the appalling behavior.

In terms of areas that frequently experience derailments, Daop 1 (Jakarta area) is an area that is prone to derailment cases. This is potentially associated with the tight schedule of the train, especially the commuter line connecting Jakarta and the suburbs. According to the Director of Safety of PT. KAI, in one day there are about 1000 trains were back and forth. Half of this amount (around 500 trains) pass through the Greater Jakarta area, which is part of the territory Daop 1.

One derailment case recently occurred is near the railway station Rangkas Sudimara, occurred on October 11, 2012. The cause of the accident is allegedly as a result of breakage (a technological environment /

facilities). However, other factors are thought to be involved due to excessive load (passengers riding on the roof of the train cars). It is clear that although the train and the infrastructure are reliable, outside factors (behavioral lack of discipline people) play an important role. In addition, there is the supervisory factor that create lack of discipline, and rules (organizational factors) that also lead to derailment. This proves that the factors causing the derailment consists of various levels of the HFACS taxonomy.

## 5. CONCLUSION

This study investigated factors that are associated with train derailments from the perspective of human factors. Human Factors Analysis and Classification System (HFACS) was utilized that uncover various factors that can contribute to train derailments in Indonesia. Half of the factors contributing to the incidents are believed to be technological in nature. It should be pointed out, however, that there are various other factors that play an important role. These include supervisory and organizational factors. Moreover,derailments can also be caused by outside factors such as theft, vandalism, and passenger behaviour. This study suggests interventions or improvement strategy that can be based on the quantitative data provided by HFACS.

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