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Operations Management for Improve Traffic Performance in Bandung City with DMAIC Six Sigma Method

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ABSTRACT

Congestion is a common issue in major cities. It causes driver fatigue, vehicle emissions, environmental pollution, and noise. Controlling pollution conditions in the city is very important for urban transport organizations such as the Ministry of Transport of the Republic of Indonesia to make traffic decisions. In this journal, we suggest a technique focused on DMAIC to increase the efficiency of urban traffic. The recommend procedure consists of three steps. In Stage 1, a survey was conducted to collect traffic congestion data in Bandung City. In Step 2, the DMAIC technique is used to evaluate the survey data obtained in Stage 1. Methods employed include the causal or Ishikawa diagram, factor analysis, six sigma control diagrams (individual and multivariate), and Pareto analysis. In Stage 3, we made suggestions to reduce traffic congestion and increase the efficiency of transport services in the region, based on Stage 1 and 2. The proposed work can be applied in practice to handling traffic congestion circumstances in the area application of the potential methodology to the City of Bandung.

Keywords
Traffic, Congestion, Six Sigma, DMAIC, Factor of Analysis.

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Introduction

Transportation has been a necessity since human civilization existed. Transportation is one way to increase the welfare of society because the entire flow of movement of people, goods, and services is strongly influenced by transportation. Transportation is a movement of people or goods by means of means or vehicles from and to geographically separated places (Steenbrink, 1974; Bowersox, 1981). Meanwhile, according to Morlok (1981), transportation is an activity or activity to move or transport something from one place to another. Soegijatna Tjakranegara (1995) defines transportation as moving goods (commodity of goods) as well as passengers from one place to another so that the carrier produces transportation services or production services for people who need to move or also ship their goods (Miro, 1997).

The development of transportation, especially land transportation, has experienced significant developments (Solow, 1972; Cascetta & Cantarella, 1993). The development of this transportation is also accompanied by the development of the problems it faces, one of which is congestion. Congestion is a common phenomenon in modern cities (Kim, 1986; Dunphy & Fisher, 1996). Rapid urbanization and progressive social practices have resulted in heavy traffic congestion in cities (Padam & Singh, 2004; Wang et al., 2019). This is a major concern of rulers and organizations, especially in centralized metropolitan cities. Traffic jam has been defined in a variety of opinions (Cooper et al., 2004; Bertini2006. Acceptance thresholds are set for these steps, and overruns result in congestion (Laetz, 1990; Smit, 2006). There are a variety of conditions that cause or exacerbate congestion. This may be attributed to a decrease in road space at a certain stage or a certain length. Almost f the traffic disruptions that appear to exist in modern cities are the result of increasing traffic volumes; much of the rest can be due to road collisions, road works, and weather conditions. Rate and flow will also affect the network's capacity, causing congestion (Systematics, 2005; LaPlante, 2007).

Bandung is a city ranked 5th based on a large population of 2,339,463 people based on data from the Ministry of Home Affairs, has a well-established transportation network including 4 sections of the Primary Arterial Road, Primary Collector Road, Secondary Arterial Road, and Secondary Collector Road as shown in Figure 1 (As-salaf, 2013). Primary arterial roads effectively connect national activity centers or between national activity centers and regional activity centers. Designed based on a plan speed of at least 60 km per hour, a minimum road width of 11 meters, long-distance traffic, local traffic, and local events should not be disrupted. The number of exits to main arterial roads is restricted and must not be interrupted. In urban areas and secondary arteries, The road connecting the primary area with the first secondary area, the first secondary area with the first secondary area, or the first secondary area with the second secondary area. Designed based on a plan speed of at least 30 km per hour with a minimum road width of 11 meters, fast traffic should not be disturbed by slow traffic (Lumba, 2009).

In the meantime, the Road Main Collector efficiently connects national activity centers and local activity centers, provincial activity centers, or regional activity centers to local activity centers. It is designed based on a plan speed of at least 40 km per hour with a minimum road width of 9 meters, and the number of entrances is limited and a secondary Collector Way linking the second secondary area to the second secondary area or the second secondary area to the third secondary area. Designed based on a design speed of 20 km per hour minimum with a way width of at least 9 meters, and fast traffic should not be disturbed by slow traffic. Soekarno Hatta street Bandung is one of the longest auto routes streets in the city. This road extends from the Cibiru roundabout to Sudirman street.

There are many interesting places on this street, from shopping centers to culinary delights. Soekarno Hatta street Bandung cuts several roads in this city, such as Buahbatu street, Moh Toha street, Kopo street, and Kiaracondong street. The four roads are roads with heavy traffic flow. As a result, traffic jams often occur at the four intersections, especially in the morning and during the day. Many of these autoroutes are sometimes caught in a rush hour. To fix congestion, the government has taken a range of steps.

An example is a plan at three intersections, namely in Kopo, Buahbatu, and Kiaracondong that a flyover will be built. With the increasing need for economic development and population immigration in Bandung, keeping the transport system working effectively will be challenging. According to their report, many traffic jams occur on the streets of the city of Bandung. Figure 1 shows the state of 2020.

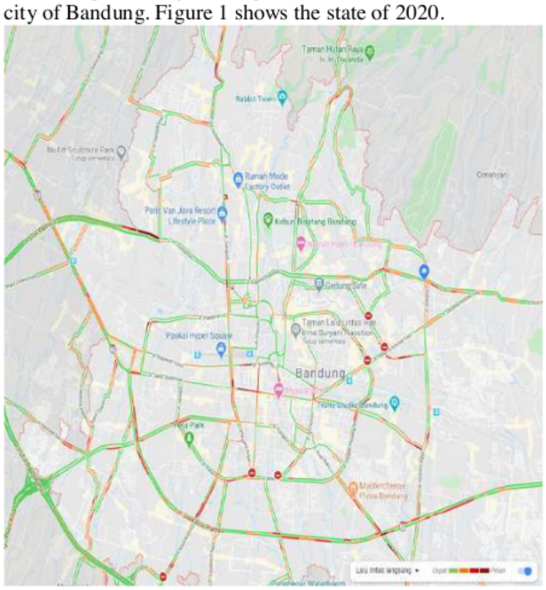

Figure 1 Congestion Streets during 6:00-9:00 AM in Bandung City

It can be seen from Figure 1 that the problem that must be solved by traffic congestion is increasing from year to year. Therefore, we need to review this problem and look for new efforts to fix it. With all these developments over the years, managing traffic well is a real challenge for the government. Based on the statistics of traffic jams, there is an increase from year to year. This is also reflected in the density of several major road areas in the city of Bandung, which affect the people of the city of Bandung. Based on the scenario above, the researcher took the initiative to research improving the quality of traffic located in Bandung by implementing lean six sigma tools and DMAIC (Susetyo et al., 2011; Wahyani et al., 2013).

Method

Traffic congestion in cities is a severe concern. Drivers spend a few hours a day on busy city highways. With a growing number of vehicles projected to fill urban streets in the coming years, the issue will become more complicated. City governments, public and private transit agencies are continually challenged to manage traffic jams in towns to build traffic conditions, cut waiting times, save energy and mitigate the effect of car pollution on urban residents and their climate. Provision and Maintenance of Public Transportation Facilities, Use of One-Way Tracks, Restrictions on Private Vehicle Ownership, Building Skywalks, Establishing Odd-Even Rules Systems, Establishing Electronic Road Pricing (ERP).

In this journal, the authors used the literature review approach; the authors found that most of these findings were observational and proposed general strategies to minimize congestion (Creswell & Poth, 2016). The solution approach to managing traffic jams in the city of Bandung consists of the following three stages: (1) questionnaire survey to gathering data on traffic jams; (2) DMAIC request to assess the response of the survey; (3) Proposing recommendations to reduce congestion at city-based sites in the outcomes of Stages 1 and 2.

Result And Discussion

Stage 1: Collection of Data Using a Questionnaire Survey

The initial move was to carry out a questionnaire survey to gather data on the traffic jam situation in the area. The questionnaire is used to gather the information needed by the researcher to analyze the issue. The structure of the questionnaire shall conform with the specification regulations (Brace, 2008) and shall contain simple, concise, and understandable questions to prevent the impatience of the respondents. To assemble the questionnaire questions, we first defined the causes of traffic jams in the area. Figure 2 displays our cause and effect diagram.

Figure 2 Cause and Impact Diagram of Road Congestion

Figure 2 indicates that bad road connectivity, road building, type of vehicle, driving behavior, and environmental factors such as temperature, crash, etc., are the main causes of pollution in urban areas. For each of these variables, Critical-to-Quality (CTQ) criteria have been established that can help to improve traffic congestion in cities. Figure 3 indicates the CTQs. The four key CTQs can be seen in Figure 3.

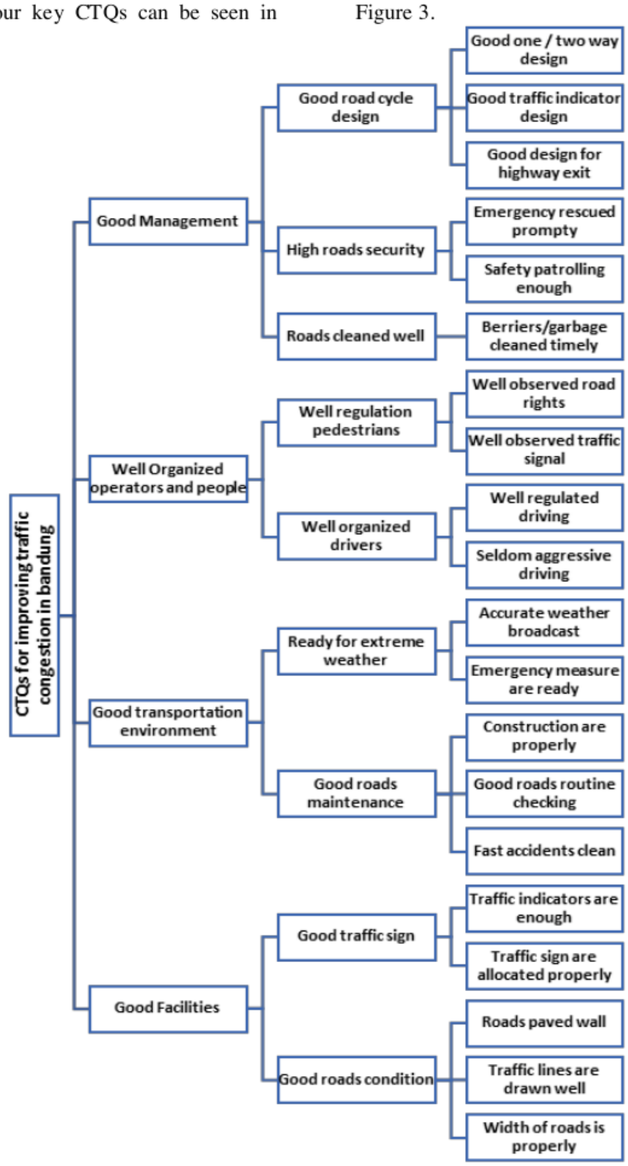

Figure 3 CTQ Tree to Improve Traffic Flow in Cities

Using the effects of the causal diagram (Figure 2) and the CTQ (Figure 3), the writers prepared questions for the survey instrument.

Stage 2: Use of DMAIC to evaluate the survey response

The second stage involves the addition of DMAIC to the polling result analysis get from stage 1. It is understood that six sigma is an efficient approach to quality control of business processes that aim to define and remove the causes of defects, malfunctions, and output errors and minimize the length of the period and running costs, improve efficiency and operation flexibility, help satisfy consumer needs, and increase asset usage and return on market financial strategies (Evans & Lindsay, 2005).

The author has chosen DMAIC or Six Sigma for monitoring and improving the performance of online-based transportation services in the city of Bandung. This study is an ongoing quality assurance strategy that helps to find long-term ways to maintain and continue to enhance services. Six sigma is consist of a 5-phase technique called DMAIC. The author defines the issue being explored in the 'Define' phase. In this situation, the challenge is to boost the efficiency of online transport services. The 'Measure' stage includes calculating data relevant to the service topic. In the 'Analyze' phase, we analyze the data collected to determine the reasons for poor performance/low quality. In the

'Analyze' phase, we examine the data obtained and determine the causes of performance/poor quality. The 'Improve' phase includes creating strategies based on an interpretation of the data gathered for enhancement. In the final stage, called 'Control,' we describe the process control steps to avoid potential defects. Figure 4 demonstrates the five-step DMAIC technique used in the Six Sigma process. In stage 2, the answers to the survey from Step 1 are subject to DMAIC (Table 1). These techniques have been selected based on their ability to analyze the service output data collected in stage 1.

Six sigma is a technique for problem-solving called DMAIC. Where DMAIC is a series of methods used to define, evaluate, and eradicate causes of variance in the process (Shafira & Mansur, 2005). The stages in six sigma, that is:

a. Definition Phase. This stage determines the expectations of the improvement effort and keeps the focus on requirements.

b. Measurement Phase, three main things must be done at this stage, namely:

1). Determine the quality characteristics of the Critical to Quality (CTQ) key that is specifically relevant to particular needs. Create a data collection strategy by calculations that can be made at the phase, source, or output stage.

2). Calculate the efficiency (current performance) of the operation, production, or level

3). Outcomes to be established as a baseline output at the start of the Six Sigma project.

c. Analysis Phase. This stage determines the factors that most influence the process, meaning looking for one or two factors, which, if corrected, will dramatically improve the process.

d. Improving Phase. This stage is to design a solution in making improvements and improving the quality of six sigma in processes that require improvement.

e. Control Phase. This phase is to control the quality and result.

Figure 4 DMAIC Process

Stage 3: Produce Suggestions Based on the findings of the DMAIC

Define Phase

At the define stage, the writer uses descriptive statistics (average value). The author uses a weighted congestion score matrix to display the degree of congestion on city roads. The weighted congestion matrix contains congestion levels, which are weighted by source location. To calculate the degree of congestion, the cumulative aggregate of the commodity must be carried out from the source weight of the area, and its relationship to the average degree of congestion in the city. The weight and importance of the contribution are given to the respondents (Table 1). These values can be found in the Table 1 column. It can be shown that the level of traffic congestion ranges from 0 to 9. Average congestion is highest at intersections, followed by toll highways, main roads, and other/local roads. Average Bandung congestion level = 58,933 (last row, Table 1).

Table 1 Matrix of Weighted Congestion Score

	Decision Criteria					
	Highways	Toll Highways	Main Roads	Intersections	Other/Local Roads	
ID	1	3	4	5	2	Total
1	1	1	1	9	1	55
2	3	3	3	9	3	75
3	1	3	3	3	9	55
4	3	3	3	9	9	87
5	3	3	9	3	3	69
6	3	9	1	3	3	55
7	3	3	3	1	3	35
8	3	3	9	9	3	99
9	9	9	3	3	3	69
10	3	1	3	3	3	39
11	1	1	1	9	1	55
12	3	9	3	3	3	63
13	1	1	3	3	9	49
14	3	3	3	1	9	47
15	0	3	9	3	3	66
16	3	9	1	3	3	55
17	0	3	3	1	3	32
18	0	0	9	3	3	57
19	9	9	3	3	3	69
20	1	1	3	3	3	37
21	1	1	1	9	1	55
22	0	0	3	9	3	63
23	1	3	3	3	9	55
24	3	3	3	3	9	57
25	3	9	3	9	3	93
26	3	9	1	3	3	55
27	3	1	3	1	3	29
28	3	3	3	9	3	75
29	9	3	3	9	3	81
30	1	1	3	3	3	37
AVERAGE	2.666666667	3.666666667	3.4	4.733333333	4	58.93333

Project Weights Menu	
0	None
1	Low
3	Mid
9	High

Measure Phase

In this step, we calculate the answers to the questionnaire to various causes concerned with congestion. Figure 1 displays the effects of different variables linked to congestion. The majority of respondents felt that the type of car, the peak hour, and the maintenance of the roads were the key causes of congestion. Six sigma is used to examine the answers in depth in Table 2. The six sigma approach is commonly used to solve problems in numerous fields (Karuppusami and Gandhinathan, 2006). The basic principle of Six sigma is product improvement by making improvements to the process to produce the perfect product/solution. The Six Sigma approach is used to identify things related to problem handling.

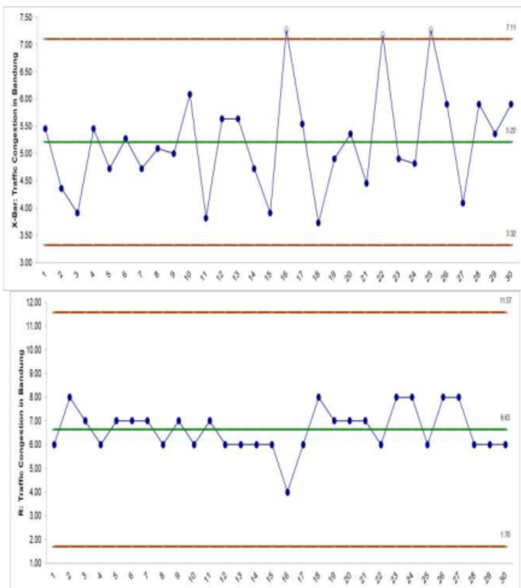

Figure 5 Six Sigma Control Chart X-Bar R Chart

Process capability is analyzed, as in Figure x. This shows the average cause of traffic jams in the Bandung city area is 5.22, and the average range is 6.63 based on the variables taken from the figure x Ishikawa diagram. Sigma 16, 22, 25 processes with sigma levels exceeding 7.11, which exceed UCL Upper Control Limit, which means high. Thus, it is evident that the process needs to be improved. The data collection is then arranged to be continued with the analysis stage.

Analyze Phase

Using the variables identified from the root cause at the measurement stage, data were collected and analyzed using statistical methods. All variables were analyzed to determine the correlation between the root causes of traffic congestion, whether significant or not. Figure 6 shows a Pareto diagram of the variables causing congestion where peak hours contribute the highest to the causes of congestion with a total contribution of 15.76%, with traffic congestion problems, namely peak hour, vehicle, construction, and aggressive driving, the 4 causes already have a share of 50.89% of the problem. Cumulatively, it shows, the process can be improved by solving problems, especially the environment and vehicle/people.

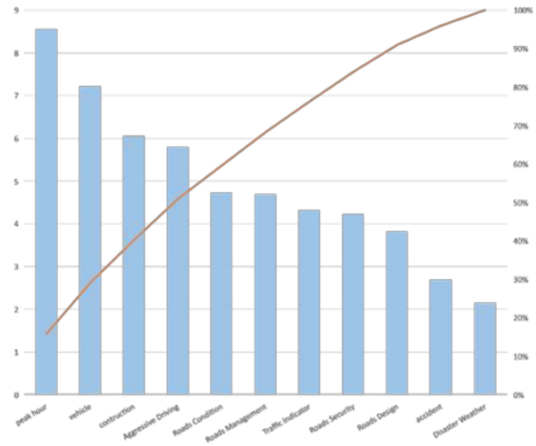

Figure 6 Pareto Chart

Data analysis, as shown in figure 6, work culture at the same time, also takes part in traffic congestion in the city of Bandung. Meanwhile, roads condition, management, and road design also have a significant role in traffic jams every day. Weather and accidents do not really affect traffic jams every day, different from the view of some people who conclude that congestion occurs due to accidents and bad weather.

Improve Phase

Causal diagrams are created at this point to define identity variables that will help improve road maintenance and road building, which in turn can improve the traffic jam situation in the region. Figure 4 provides a cause and effect diagram for the improvement of road and road development in Bandung. The following diagram shows that improved infrastructure, the function of a suitable approach.

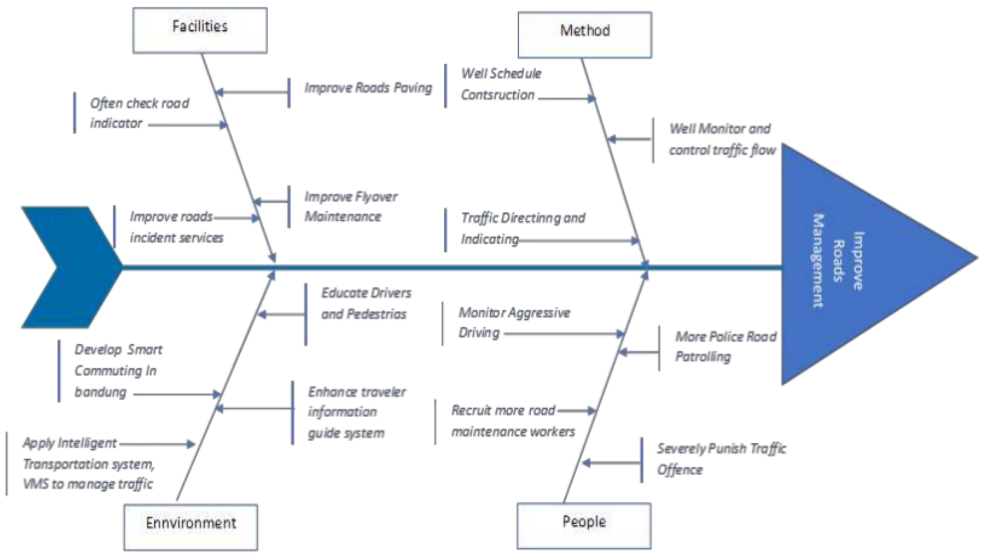

Figure 7 Cause and Impact Diagram for Improving Road Maintenance

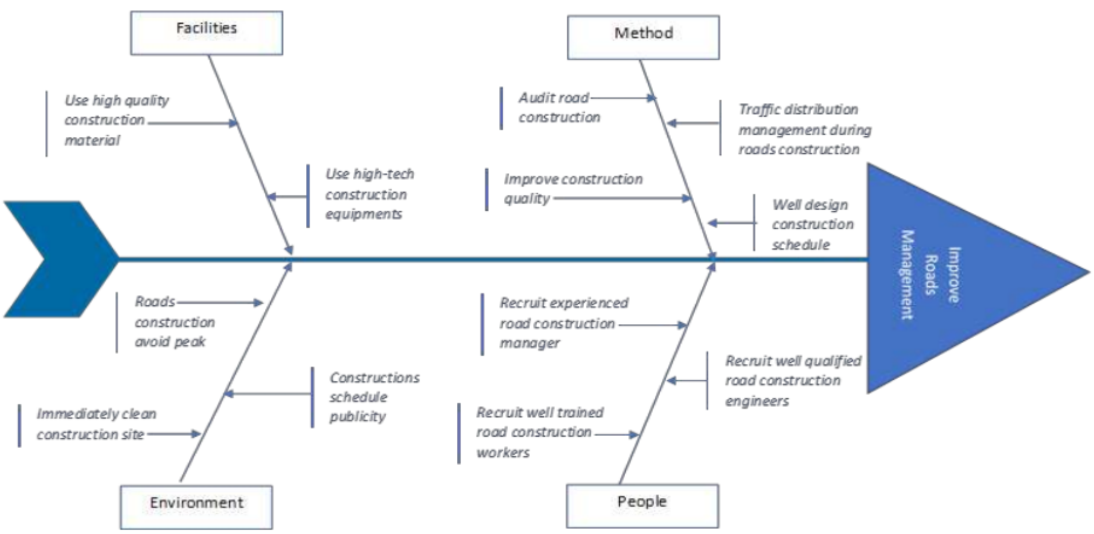

Figure 8 Reason and Impact Diagram to Boost the Construction of Roads

Control Phase

Mechanism of Control is the last stage of the DMAIC. This guarantees that additional traffic can be managed by periodically measuring traffic jam-causing variables and taking corrective steps to repair issues and restore the mechanism to consistent results. To handle and enhance traffic congestion in Bandung Region, we suggest using person control maps (x-bar and R) (Montgomery, 2005). From the DMAIC report, the authors find that improving traffic maintenance and road building is very critical in overcoming congestion (figure Pareto). Therefore, based on the findings of the six sigma questionnaire survey and the DMAIC, it may be said that the two results are consistent.

Conclusion

From this study, the authors recommend three forms to reduce traffic congestion in the city. (1) a questionnaire survey to collect data about the traffic jam situation in the area. (2) the DMAIC technique was applied to the survey data from the first way. The method used is the Six Sigma System, Cause and Effect Diagrams, Factor Analysis, and Pareto Diagrams. (3) to reduce traffic congestion in the cities determined using the impact of Steps 1 and 2, a case study was carried out in Bandung.

The existence of construction and repair is the main cause of congestion in the city of Bandung, which causes traffic jams at rush hour. Key proposals for reform include enhancing road safety, improving public transport, having flexible working hours, and restricting the movement of vehicles.

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