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Asymmetry of Authority or Information Underlying Insufficient Communication Associated with a Risk of Crashes or Incidents in Passenger Railway Transportation

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Abstract: Similar crashes or incidents may recur as a result of insufficient communication in uncertain and risky situations that potentially threaten safety. The common root causes of insufficient communication across a series of incidents and crashes must be explored in detail to prevent a vicious circle of similar incidents or crashes from occurring. This study summarizes a series of incidents and crashes (derailment due to excessive train speed) at JR West at the West Japan Railway Company (JR West) that are considered to have arisen from insufficient communication. The incidents included (i) resuming train service without confirming the number of passengers on board and leaving passengers behind the station at Higashi-Hiroshima station, (ii) continuing train service in spite of an apparent risk of a crash detected at Okayama station, and (iii) leaving the crack of the train hood as it was at Kokura station. We discuss the causes of insufficient communication (particularly in relation to the sharing of information) among the three branches of staff—the station staff, the conductor and train driver, and the train operation management center—that led to the incidents or crashes. Two factors contributed to the insufficient communication in the series of incidents and crashes: (a) Asymmetry of authority, which hinders the discussion of issues openly and equally among the branches concerned. (b) An unacceptable level of knowledge or information for all branches concerned.

Keywords: passenger railway transportation; crash; incident; insufficient communication; risk; asymmetry of authority

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1. Introduction

Careful and accurate communication is critical in a variety of activities and services, such as air traffic, train or medical treatment services. Open and accurate communication among staff is indispensable for safety. Insufficient communication is likely to lead to incidents, crashes or malpractice, thus claiming many lives [1–13]. Barshi and Farris [14] have discussed misunderstandings in aviation ACT communication from the perspectives of linguistic properties and cognitive workload in communication. Owen [15] has discussed human factors in emergency management and has shown that more open communication styles facilitate more effective intra- and inter-team communication.

Open communication allows team members to share information and enhances their comprehension of the situation. However, open communication is difficult when asymmetry of information [16] or authority exists. The concept of asymmetry of information was first proposed in economics and represents a situation in which one group has more information than the other. This asymmetry creates an imbalance of power in a variety of situations and leads to failures in economic activity, such as moral hazards or monopolies of information, and hinders open communication, particularly in relation to the sharing of information.

Many studies have been conducted on team cooperation and communication [9,17–22]. Stahl [23] has proposed that understanding the characteristics of inter-group interactions is important for enhancing team or group performance. Miller et al. [21] have shown that a complex decision structure with different role holders must be considered in intensive care unit communication so that miscommunications leading to malpractice can be prevented. Keyton and Beck [18] have stated that sharing information is essential for open communication. Therefore, communication consisting of sufficient sharing of information must be practiced to prevent incidents or crashes. Crew resource management is considered an effective means to ensure safety in a variety of railway transportation services, such as aviation or train services [9].

Insufficient communication is well recognized to trigger failures and eventually lead to incidents or crashes in complex and large-scale systems such as railway transportation services. However, the reasons why insufficient communication occurs have not been fully explored. The following behaviors are not sufficient for preventing a vicious cycle of similar incidents or crashes from occurring [24]: apologies in response to crashes or incidents, and announcements of efforts for appropriate communication among staff without an exploration of the causes of insufficient communication. Few studies have discussed how the causes of insufficient communication create an undesirable state leading to incidents or crashes.

The goal of communication is to recognize the meaning of information accurately, exchange opinions bilaterally and equally (without asymmetry of authority or information) and achieve an aim, such as enhanced safety or efficiency, through cooperation. Various types of miscommunication exist. The most general miscommunication corresponds to a situation in which information A from one side cannot be transmitted to the other side as A. Even if information A from one side is correctly transmitted to the other side as A, its meaning or interpretation might differ between sides. Generally, such types of miscommunication are considered to cause crashes or medical malpractice in complex and large-scale systems such as air traffic, train or medical services.

Communication error has become a leading cause of incidents in healthcare activities [25,26]. Swift [27] has reported that communication failures contributed to 27% of medical malpractice claims between 2012 and 2016. On the basis of incident reports submitted by pilots and air traffic controllers, Wilso [28] has found that more than 70% involve problems in communication. Tanino et al. [29] have reported that 38 of 148 railway incidents at JR West were caused by communication errors. Omino [30] has reported 1706 cases associated with communication errors in JR groups (JR Hokkaido, JR West, JR East, JR Kyushu and JR Tokai) between 1990 and 2016. Thus, communication errors contribute to incidents or accidents to a large extent, and improving insufficient communication among the branches is crucial to prevent severe incidents or accidents.

Other types of miscommunication hinder the sharing of information. The lack of transmission of information A to one side, owing to the possession of information A by the other side or the greater authority of the other side, induces miscommunication. If one branch with greater authority is not willing to listen to and accept the important information A transmitted by the other branch, the sharing of information and the open communication between branches is hindered. Such types of miscommunication as a cause of crashes or incidents are based on symmetry of authority or information and have not been fully explored. Such types of miscommunication are expected to be triggered by a closed or immature organizational safety culture or biased authority [31].

Since the derailment and crash of its Fukuchiyama line on 25 April 2005 [32–34], JR West has repeatedly caused incidents at Okayama station [35–38] and Kokura station [39,40]. Although these incidents fortunately did not lead to disastrous crashes like that on the Fukuchiyama line, we sought to explore why similar incidents occurred repeatedly, learn from these incidents, and develop countermeasures to prevent another crash. We sought to examine the repetition of similar incidents or crashes by identifying factors common to the incidents, to extract a root cause from detailed analysis of similar incidents or crashes.

Molesworth and Estival [26] have shown that communication performance is degraded when the workload imposed on pilots is excessive, and have concluded that external factors contribute to miscommunication. The risk of incidents or accidents caused by insufficient communication between a sender and a receiver is generally well recognized. To prevent incidents or accidents associated with insufficient communication, recognizing the triggers of insufficient communication in detail is necessary. However, few studies have addressed incidents or accidents caused by insufficient communication from the viewpoints of asymmetry of authority and unacceptable levels of knowledge or information.

The research hypothesis in this study was that insufficient communication was common among similar incidents or crashes, which recurred because of a lack of countermeasures to remove the root causes and prevent insufficient communication. Moreover, we hypothesized that asymmetry of authority or information and unacceptable levels of safety-related knowledge or information underlie insufficient communication.

Miscommunication or insufficient communication in complex and large-scale systems, such as passenger railway transportation systems, can cause fatal crashes. We investigated the issue of insufficient communication underlying a series of incidents and crashes that occurred at JR West. This study addressed the causes of insufficient communication (concerning the sharing of information) among the relevant staff in a series of incidents and crashes, which potentially pose safety-threatening risks. We additionally explored why similar insufficient communication repeatedly occurred, from the viewpoints of asymmetry of authority or information and unacceptable levels of knowledge or information, owing to an underdeveloped open safety culture.

2. Similar Cases (Incidents or Crashes) at JR West Caused by Insufficient Communication

2.1. JR West Higashi-Hiroshima Station Incident

The incident is based on the formal documentation of JR West (JR West formal document number: 180708–000121 & 180802–000236). The JR West Hiroshima branch agreed that the incident could be reported in an academic journal on the condition that valuable lessons be extracted from the analysis of the incident to prevent subsequent incidents. The outline of the incident is described below.

As rain continued, the readings of multiple rain gauges installed between Hiroshima and Higashi-Hiroshima exceeded the reference value predetermined by JR West. At Higashi-Hiroshima station, JR West formally announced to the passengers that continued train service was impossible because of the weather situation (particularly the rain) and the time needed for inspection and confirmation of safety.

Kodama No. 751 arrived at Higashi-Hiroshima station at 6:28 p.m., where its service was suspended to allow the train operation management to monitor the situation and assess whether further train service was possible. JR West later formally announced to the passengers and the staff at Higashi-Hiroshima station that the train would stay at Higashi-Hiroshima station, and service would not be resumed until the following day.

On the basis of this announcement, some passengers quickly booked overnight hotel accommodations near Higashi-Hiroshima station. Moreover, many passengers went to a nearby convenience store to purchase their dinner. The passengers received confirmation from the station staff that train service would not resume until the next day, obtained permission from the station staff to leave the station and went to a convenience store to get dinner. Notably, JR West was unable to confirm the number of passengers and their situations (whether they stayed in the train compartment, booked a hotel room for one night or went to a convenience store to buy dinner).

JR West inspected the railroad track and confirmed that it was safe because the rain had decreased to a drizzle and was below the reference value for suspending train service. At 9:03 p.m., JR West decided to resume train service to Hiroshima station. In this manner, the first decision to stay at Higashi-Hiroshima station until the next day was suddenly revoked. Bound for Hiroshima station, the train left Higashi-Hiroshima station at 9:27 p.m.

Although JR West knew that many passengers were on board, they did not recognize the exact number of passengers on board when they decided to suspend train service until the next day and made the according announcement. Consequently, the number of passengers under such an uncertain situation could not be confirmed, and the behavior of the passengers could not be completely understood. Therefore, the likelihood that passengers were left behind at the station was high. However, JR West did not predict such a situation at all. Open communication (exchange in opinions on the appropriateness of the sudden decision change) among the staff is likely to be difficult in urgent and uncertain situations. The outcome of changing the initial decision was that train service was resumed without confirmation that all passengers were on board; consequently, many passengers were left behind at Higashi-Hiroshima station.

2.2. JR West Fukuchiyama Line Crash

On 25 April 2005, a train derailed between Tsukaguchi and Amagasaki station, JR West Fukuchiyama line, and hit an apartment building; 106 people were killed (including a train driver), and 562 people were injured [32–34]. The train exceeded the pre-specified speed limit of 70 km/h, thus causing the first and second cars to collide with the apartment building. The automatic train stop system was not equipped with the track of the crash. The investigation concluded that the direct cause of the crash was speeding. The train had overshot the predetermined stopping position at Itami station before leaving for Amagasaki station, thus resulting in a 90 s delay. The train driver broke the speed limit to recover from the delay.

Train drivers face financial penalties for delayed train service and are forced to participate in harsh, humiliating retraining programs known as nikkin kyoiku ("dayshift education"), including weeding and grass-cutting duties unrelated to the improvement of driving skills. Ten months before the crash, the train driver had been reprimanded for overshooting a station platform. Therefore, the train driver is speculated to have been nervous about overshooting at Itami station, to have worried about the punishment for having overshot the platform and to have been unable to concentrate on safe driving. The insufficient communication among the staff is discussed in detail in Section 3.2.

2.3. JR West Okayama Station Incident

On 19 December 2017, JR West announced that a crack found in an undercarriage of a Shinkansen bullet train on 11 December 2017 was approximately 44 cm in total from one side of the undercarriage frame to the other [35–38]. The joint that transmits motor motions to the gears was displaced, and the frame was deformed because of the crack, which was about to break the frame and could have led to a derailment.

Approximately 20 min after the train left Hakata station for Tokyo station on 11 December 2017, at least one conductor noticed a burning smell. As the train approached Okayama station, a passenger reported to a conductor that the air inside the train was foggy, so the maintenance staff boarded the train at Okayama station and inspected the failure. Although the maintenance staff confirmed an abnormal groaning sound and insisted that train service should be discontinued, the staff at the Shinkansen general command center judged that the sound would not affect safety and made a decision to continue train service. Without heeding the warning by the maintenance staff at Okayama station that the risk of derailment was high, the general command center decided to continue train service. Despite the detection of an abnormal odor near Kyoto station, the train continued its service before it was forced to stop at Nagoya station. Experts have warned that if the carriage had been fractured, the train could have been derailed and resulted in a serious crash. JR West formally admitted that the operator in the train operation management center made a judgement error in responding to the report of an abnormality by the maintenance staff at Okayama station.

2.4. JR West Kokura Station Incident

At around 2 p.m. on 14 June 2018, approximately six months after the Okayama station incident, a Shinkansen bullet train bound for Tokyo hit a man who entered the track area

between Hakata and Kokura station without permission and committed suicide [39,40]. The train hit the man inside a tunnel approximately 17 km before Kokura station. Although the hood of the train was cracked in the incident, none of the passengers were injured. The train driver noticed an abnormal sound when the hood was damaged. Therefore, JR West should have immediately inspected the train at the Kokura station to confirm whether further train service was possible.

According to the operation center of the Sanyo Shinkansen bullet train, a Kokura station employee found smeared blood on the train's cracked hood. However, the station staff reported the matter to the operation center only after the train had left Kokura station. In response to the above-mentioned incident at Okayama station approximately six months earlier, JR West announced that they would conduct employee training to ensure that train service would be suspended for inspection and safety assurance whenever abnormalities were detected. JR West also required train drivers and station staff to report even subtle abnormalities to an operation center as soon as possible. Contravening this requirement, the train driver and the station staff did not report the abnormality detected at Kokura station.

The repeated occurrence of similar incidents or crashes based on insufficient communication provides solid evidence that the investigations have been superficial and have not scientifically identified the root cause common to series of incidents and crashes. Investigating why similar insufficient communication-based incidents or crashes occurred is necessary to prevent the recurrence of similar incidents or crashes.

3. Discussion: Asymmetry of Authority and Unacceptable Levels of Knowledge or Information that Inhibit Open Communication

Although insufficient communication among staff apparently contributed to the incidents and crashes in Section 2, an exploration is necessary to assess why sharing of information (enabling open communication among the staff) was impossible and the insufficient communication induced incidents or crashes. The causes common to the four cases above are discussed from the viewpoint of insufficient communication arising from asymmetry of authority and unacceptable levels of knowledge or information.

3.1. JR West Incident at Higashi-Hiroshima Station

In the urgent situation that occurred at Higashi-Hiroshima station, none of the staff noticed the risk of leaving passengers behind at the station after the sudden decision change made under uncertainty (the number and behavior of the passengers were uncertain and unknowable). The strong authority of the train operation management (general command center) must have compelled the other branches (station staff and conductor and train driver) to blindly obey the general command center's command and prevented them from predicting the risks accompanying the sudden decision change. The asymmetry of authority hindered open communication among the branches.

Figure 1 shows that the three branches did not have equal authority. In addition, they lacked the appropriate information or knowledge necessary for providing safe train service and facilitating communication among the staff. The bold line with one arrow represents the one-way (non-interactive) communication between two branches. The thin line with arrows on both sides shows weak communication between two branches, a case corresponding to the incident at Higashi-Hiroshima station, JR West.

Although the information or knowledge level must be above an acceptable level to enable open communication of risks and safety issues in uncertain situations, the knowledge or information level (the safety-critical knowledge, expertise or skills necessary for decision-making under uncertainty and risk) of the three branches in this incident must have been below the acceptable level, as described in the previous section (Figure 1). The unacceptable knowledge or information also caused insufficient communication among staff under the uncertain and risky situation.

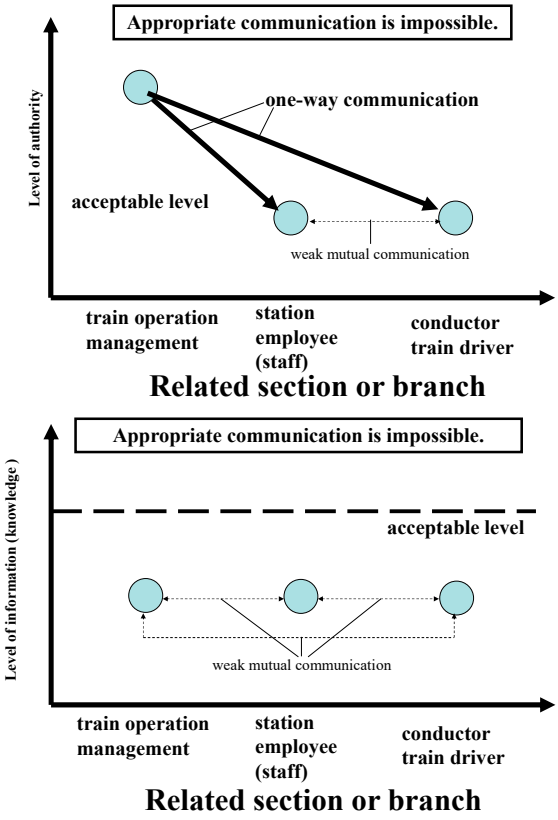


Figure 1. Asymmetry of authority of the related section or branch (train operation management, station staff, and conductor and train driver) and the unacceptably low level of information (knowledge) leading to insufficient communication and hindering open discussion.

3.2. JR West Fukuchiyama Line Crash

Strong authority of the train operation management was also observed in the derailment and crash on JR West's Fukuchiyama line (Section 2.2). Although the direct cause of the derailment and crash was excessive speed of the train, insufficient communication among the station staff, the conductor and train driver, and the general command center of operation management forced the train driver to speed, because the train driver feared being blamed by the general command center for the delay. Because the authority of the train operation management was greater than that of the train driver (asymmetry of authority), as shown in Figure 1, the train driver could not admit to operational failure and thus attempted to speed, to compensate for the delay and thus conceal the failure from the train operation management. Even in this case, an insufficiently developed open safety culture caused asymmetry of authority and hindered sharing of information among the staff (regarding the delay of service because of to the train driver's failure (overshooting the predetermined stopping position at Itami station). In this manner, the train driver exceeded the speed limit.

As described by Syed [41] and Dekker [42], such a situation is caused by the absence of an open safety culture that promotes sufficient communication among staff without a fear of blame for operational failure. Dekker [42] has suggested that placing blame undermines workers' ability to learn from failures and instead decreases the openness of failures. Syed [41] has also described that fully disclosing incidents is necessary to learn from failures and foster an open safety culture. If the train operation management had equal authority to that of the other branches, and an open safety culture was in place that emphasized no blame for failures, the train driver might have openly admitted to operational failure at Itami station without fear of being blamed and might have avoided violating the speed limit. Fostering such an open safety culture leads to open communication among staff. Murata [43] and Murata and Karwowski [44] have suggested that cultural factors that

hindered open discussion or communication regarding safety issues among Tokyo Electric Company, the regulators and the government led to several organizational failures in managing emergencies in the Fukushima Daiichi disaster.

3.3. JR West Okayama Station Incident

Strong authority of the train operation management was also identified in the incident at Okayama station (Section 2.3). The maintenance staff at Okayama station confirmed an abnormal groaning sound and insisted that train service should be discontinued. However, the staff at the Shinkansen general command center optimistically concluded that the sound would not affect safety and decided to continue train service. Although an abnormal odor was detected near Kyoto station, the train continued service until Nagoya station. The maintenance staff members at Okayama station were unable to disobey the decision of the general command center, owing to asymmetry of authority, as shown in Figure 1.

The staff members with the greatest authority were unwilling to heed the proposal by the maintenance and inspection experts, thus indicating that asymmetry of authority hindered open communication regarding the risk of train crash and the recognition of the risk. Although JR West required all staff to report even subtle events with a risk of threatening transportation safety, the incident at Kokura station (Section 2.4) nonetheless occurred. Therefore, countermeasures to eliminate asymmetry of authority or information appear to have been insufficient. Even subtle safety-critical information cannot be reported if the asymmetry of authority hinders open discussion. Therefore, some countermeasures to eliminate the asymmetry of authority are necessary for open discussion of safety-critical events among staff without asymmetry of authority, as shown in Figure 2.

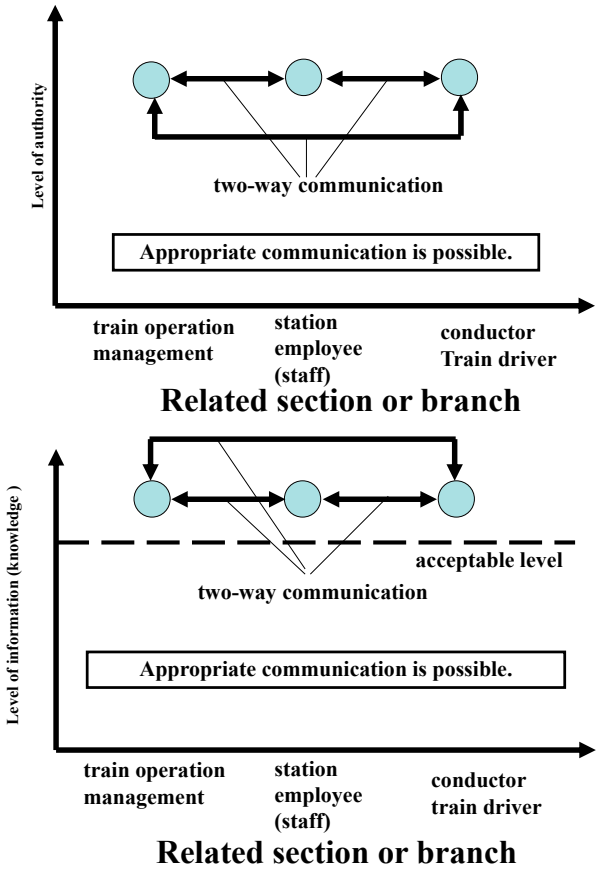


Figure 2. Appropriate authority level of the related section or branch (train operation management, station staff, and conductor and train driver) and the threshold level of information (knowledge) above which open communication is not hindered.

3.4. JR West Kokura Station Incident

Although the information or knowledge level must exceed the acceptable level to enable open communication regarding risks and safety issues under uncertain situations, the knowledge or information level (safety-critical knowledge, expertise or skills necessary for decision-making under uncertainty and risk) of the three branches in this incident was unacceptably low, as shown Figure 1. The asymmetry of information is apparent in this case, because only the train driver and the Kokura station staff had the knowledge that the nose of the Shinkansen bullet train was damaged by an unknown cause. Staff other than the train driver had no information on the damage to the bullet train's nose. The unacceptable knowledge or information must have caused insufficient communication among the staff under the uncertain and risky situation. In the Kokura station incident (Section 2.4), only the train driver and the Kokura station staff had access to the safety-critical information when the train arrived at Kokura station. Although the damage to the hood did not affect the safe operation of the Shinkansen bullet train, the damage should have been quickly and appropriately inspected at the Okura station to confirm whether the safety of train operation was hindered and further operation was possible.

The information or knowledge level must exceed the acceptable level and have no asymmetry, to enable open communication about risks and safety issues (Figure 2). The knowledge or information level (the safety-critical knowledge, expertise or skills necessary for decision-making under uncertainty and risk) of the three branches in the Kokura station incident was asymmetric and below the acceptable level to promote open communication.

3.5. Summary

Because the Kokura station incident occurred shortly (six months) after the Okayama station incident, this incident was criticized severely by many newspapers and television broadcasts. After the Okayama station incident, JR West formally announced that they had introduced a rule requiring all safety-critical information to be shared among staff to increase railway transportation safety. Even after the Fukuchiyama line crash, JR West formally announced that they prioritize the safety of passengers above all. However, similar incidents have recurred, thus indicating that the root cause of the insufficient communication, such as asymmetry of authority, had not been recognized, and these incidents and crashes were not taken seriously. JR West does not appear to have a mindset of learning from similar incidents and improving the communication skills of the three branches to enhance the provision of safe train service.

As shown in Figure 2, the three branches must have equal authority, and their knowledge or information must exceed the acceptable level to permit open discussion of risk and safety, which is necessary for open communication and enhanced safety. The bold line with arrows on both sides represents a bidirectional (interactive) and appropriate communication. If the information or knowledge of all staff is below the acceptable level, as in the case of the Higashi-Hiroshima station (Section 2.1) or Kokura station incident (Section 2.4), the staff cannot recognize safety-critical information. Under asymmetry of authority, as in the Higashi-Hiroshima station incident (Section 2.1), Fukuchiyama line crash (Section 2.2) or Okayama station incident (Section 2.3), the staff cannot discuss safety-critical issues openly and communicate. High authority does not necessarily correspond to deep insights into safety-related issues, and asymmetry of authority and unacceptable levels of knowledge or information might plausibly lead to incidents or crashes. Factors such as asymmetry of authority have been extensively discussed and linked to the concept of safety culture [31,45,46] or psychological safety [47–49].

A lack of open discussion regarding risks (including an exchange in opinions and sharing of information) hinders cooperation to discuss safety-critical issues, such as the risk of incidents, to eliminate asymmetry of authority or information, and to increase information or knowledge levels. In the Fukuchiyama crash, the Higashi-Hiroshima station incident and the Okayama station incident, the train operation management staff did not allow the staff directly in charge of train operation to express their opinions openly, thus

forcing them to obey the command with high authority. As indicated by Antonsen [31,45], an underdeveloped open safety culture leads to exceedingly strong and unilateral authority of one branch. Such an environment hinders the open communication that would enable staff to openly discuss risks that threaten safety.

We discussed how an underdeveloped open safety culture caused asymmetry of authority and an unacceptable level of information, thus hindering sufficient communication. Antonsen [31,46] has defined safety culture as the frame of reference through which safety-critical information or knowledge is interpreted and appropriately communicated. Weick [50] has stated that safety culture is a source for maintaining safety by serving as a medium for the communication of safety-critical knowledge or information. Antonsen [45] has emphasized the importance of two-way (bidirectional or interactive) communication. Owen [15] has shown the importance and effectiveness of open communication styles.

The lack of knowledge to manage risks under uncertainty and the communication-inhibiting effect of asymmetry of authority, as shown in Figure 1, prevents the teamwork necessary for open communication and high performance [47–49,51]. The placing of blame for failures does not necessarily prevent similar failures from recurring. As seen in the derailment and crash of JR West's Fukuchiyama line, this framework decreases openness in failures, and important information is buried, or violations are committed to avoid punishment or blame.

To promote sufficient communication and prevent similar incidents or crashes to the crash in JR West's Fukuchiyama line and the incidents at JR West's Okayama, Kokura and Higashi-Hiroshima station, two factors must be reduced as much as possible by fostering a mature open safety culture and highly reliable organization [52–55] (Figure 3):

(a) Asymmetry of authority, which hinders sufficient communication to promote open discussion of safety issues among the relevant branches.
(b) An unacceptable level of knowledge or information for all relevant branches.

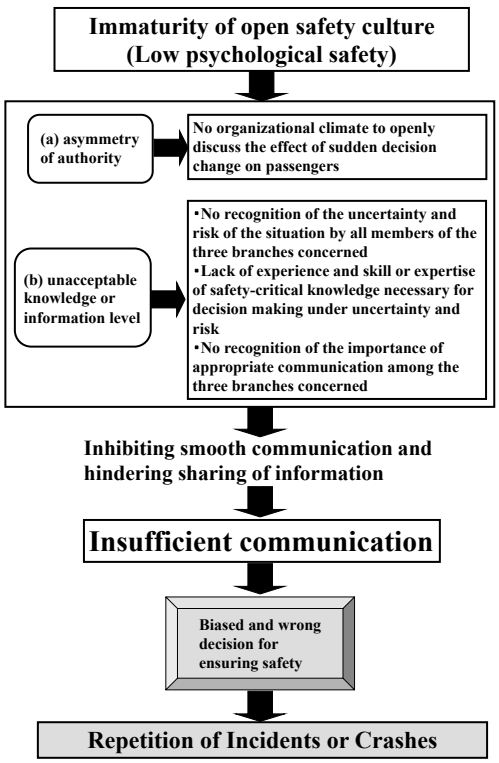


Figure 3. Flow from an immature safety culture to (**a**) asymmetry of authority and (**b**) unacceptable knowledge or information levels to insufficient communication, which contribute to incidents or crashes.

A high-reliability organization must practice continuous learning through feedback from its own and others' experiences of failure, adopt collective mindfulness toward safety within the organization and foster a climate of open discussion on safety-related issues so that factors (a) and (b) above do not lead to similar incidents or crashes arising from insufficient communication.

4. Countermeasures for Removing Asymmetry of Authority and Enhancing Safety-Related Knowledge or Information

This study demonstrated that similar incidents or crashes recur when organizations do not fully recognize the safety-threatening risk of insufficient communication and attempt to remove causes (a) and (b) of insufficient communication, as stated in Section 3.5. Open communication promotes the sharing information by all members of an organization and enables accurate comprehension of the situation. Therefore, to enable open communication, a safety climate must be fostered in which team members can speak up, exchange constructive opinions and learn from failures, as suggested by Syed [41]. As shown in this study, such a climate of open communication is difficult to create if asymmetry of authority or shared information exists. An organization should recognize an undesirable flow from an immature open safety culture to a failure of communication, as shown in Figure 3.

How to improve asymmetry of authority and unacceptable knowledge or information, which are risk factors for insufficient communication, remains an important issue for preventing incidents or accidents that stem from insufficient communication. We described how the asymmetry of authority can be removed and the level of safety-related knowledge or information can be increased. Inter- and intra-branch open discussions on safety-related issues should be promoted through use of the following checklist. If each member has negative feelings regarding the items below, the organization should take measures to eliminate such negative feelings.

(1) The knowledge or information on safety-related risks is shared by all members within branches so that the level of safety-related knowledge or information is enhanced;
(2) All members at each branch can speak up regarding safety-related issues on their minds;
(3) Each branch can openly discuss safety-related issues with other branches.

Moreover, the following properties of high-reliability organizations should be fostered to design a communication environment that enables workers to discuss issues openly, collectively collaborate within an organization and avoid insufficient communication as much as possible:

(4) Continuous learning through feedback from the organization's own failure experience and those of others;
(5) Collective mindfulness toward safety within the organization;
(6) Climate of open discussion of safety-related issues.

Judgments regarding operational safety without pressure from other branches due to asymmetry of authority must also be enforced without placing blame, even if the judgment impairs efficiency. The following countermeasures might be effective for promoting the sharing of information and open communication. If an issue raised by one branch is not resolved, and a solution to the issue is not fully agreed on by all branches concerned, a decision to proceed with the solution should not be made. That is, when safety-related issues are raised by one branch or one member in a branch, the next step should be suspended until all branches agree that the safety issues have been addressed appropriately, and no such issues remain. In this way, open communication supported by an open safety culture is promoted, thus supporting the provision of safe railway transportation.

The knowledge and skills associated with handling risks under uncertain situations should be enhanced routinely through open discussion among the involved branches. Excessively relying on other branches because of the asymmetry of authority under low psychological safety (safety culture) hinders willingness to master knowledge, acquire

information, and increase knowledge and information regarding the safety-related issues necessary for mitigating and preventing incident risk. Thus, the removal of asymmetry of authority, the assurance of each branch's independence through the countermeasures described above and enhancing psychological safety (open safety culture) are essential. This conclusion is consistent with that of Antonsen [31,46], who has examined the safety-threatening risk of inter-group asymmetries in power and status on offshore supply vessels. Antonsen [56] and Alvesson [57] also suggested the need of practice to remove asymmetry of authority and create an open safety culture, which supports the discussion of this study. The discussion for removing asymmetry of authority and enhancing safety-related knowledge or information is summarized in Figure 4.

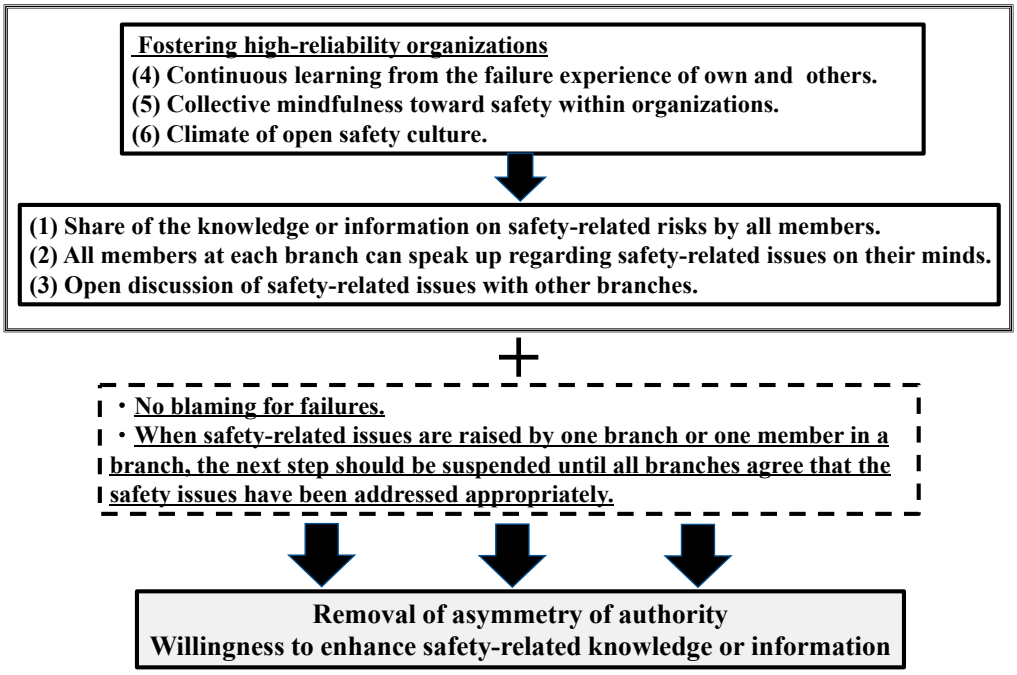


Figure 4. Summary of countermeasures for removing asymmetry of authority and enhancing knowledge or information level.

5. Conclusions

On the basis of a discussion of why insufficient communication leads to a series of similar incidents or crashes, this study explored the in-depth causes of insufficient communication. The conclusions can be summarized as follows.

(1) The asymmetry of authority, and unacceptable knowledge or information levels underlying the insufficient communication, contribute to the occurrence of similar incidents or crashes.
(2) An underdeveloped open safety culture causes asymmetry of information and unacceptable knowledge or information levels, thus preventing sufficient communication among staff, because a wrong decision or behavior is unlikely to be corrected under strong authority that hinders open discussion.
(3) Without eliminating asymmetry of authority and enhancing knowledge or information levels, similar incidents or crashes recur, particularly in large and complex systems such as railway transportation systems.
(4) Fostering a high-reliability organization with a climate of continuous learning, collective mindfulness and open discussion of safety-related issues can remove factors such as asymmetry of authority, thus promoting open communication and preventing additional incidents or crashes.

Future research should verify the validity of the findings in fields other than railway transportation systems (e.g., air traffic or medical services). Future study should also conduct a simulation study to verify the findings.

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References

1. Burke, C.S.; Stagl, K.C.; Salas, E.; Pierce, L.; Kendall, D. Understanding team adaptation: A conceptual analysis and model. *J. Appl. Psychol.* **2006**, *91*, 1189–1207. [CrossRef] [PubMed]
2. Carson, J.B.; Tesluk, P.E.; Marrone, J.A. Shared leadership in teams: An investigation of antecedent conditions and performance. *Acad. Manag. J.* **2007**, *50*, 1217.
3. Comfort, L.K.; Kapucu, N. Inter-organizational coordination in extreme events: The World Trade Center attacks, September 11, 2001. *Nat. Hazards* **2006**, *39*, 309–327. [CrossRef]
4. Fiore, S.M. Interdisciplinarity as teamwork: How the science of teams can inform team science. *Small Group Res.* **2008**, *39*, 251–277. [CrossRef]
5. Hackman, J.R.; Wageman, R. A theory of team coaching. *Acad. Manag. Rev.* **2005**, *302*, 269–287. [CrossRef]
6. Hambley, L.A.; O'Neill, T.A.; Kline, T.J. Virtual team leadership: The effects of leadership style and communication medium on team interaction styles and outcomes. *Organ. Behav. Hum. Decis. Process.* **2007**, *103*, 1–20. [CrossRef]
7. Langan-Fox, J.; Anglim, J.; Wilson, J.R. Mental models, team mental models, and performance: Process, development, and future directions. *Hum. Factors Ergon. Manuf.* **2004**, *14*, 331–352. [CrossRef]
8. Mathieu, J.; Maynard, M.T.; Rapp, T.; Gilson, L. Team Effectiveness 1997-2007: A Review of Recent Advancements and a Glimpse into the Future. *J. Manag.* **2008**, *34*, 410–476. [CrossRef]
9. Salas, E.; Rhodenizer, L.; Bowers, C.A. The design and delivery of crew resource management training: Exploring available resources. *Hum. Factors* **2000**, *42*, 490–511. [CrossRef] [PubMed]
10. Taggar, S.; Seijits, G.H. Leader and staff role-efficiency as antecedents of collective-efficacy and team performance. *Hum. Perform.* **2003**, *16*, 131–156. [CrossRef]
11. Volpe, C.E.; Cannon-Bowers, J.A.; Salas, E. The impact of cross-training on team functioning: An empirical investi-gation. *Hum. Factors* **1996**, *38*, 87–101. [CrossRef]
12. Weick, K.E.; Sutcliffe, K.M. *Managing Unexpected: Assuring High Performance in An Age of Complexity*; Jossey-Bass: San Francisco, CA, UAS, 2001.
13. Salas, E.; A Rosen, M.; Burke, C.S.; Nicholson, D.; Howse, W.R. Markers for enhancing team cognition in complex environments: The power of team performance diagnosis. *Aviat. Space Environ. Med.* **2007**, *78*, 77–85.
14. Barshi, I.; Farris, C. *Misunderstandings in ATC Communication-Language, Cognition, and Experimental Method-ology*; Ashgate: Farnham, UK, 2013.
15. Owen, C. *Human Factors Challenges in Emergency Management-Enhancing Individual and Team Performance in Fire and Emergency Services*; Ashgate: Farnham, UK, 2014.
16. Akerlof, G.A. The Market for "Lemons": Quality Uncertainty and the Market Mechanism. *Q. J. Econ.* **1970**, *84*, 488–500. [CrossRef]
17. Salas, E.; Cooke, N.J.; Gorman, J.C. The science of team performance. *Hum. Factors* **2010**, *52*, 344–346. [CrossRef]
18. Keyton, J.; Beck, S.J. Perspective: Examining communication as metacognition in STS. *Hum. Factors* **2010**, *52*, 335–339. [CrossRef]
19. DeChurch, L.A.; Zaccaro, S.J. Perspectives: Teams won't solve this problem. *Hum. Factors* **2010**, *52*, 329–334. [CrossRef] [PubMed]
20. Bearman, C.; Paletz, S.B.F.; Orasanu, J.; Thomas, M.J.W. The breakdown of coordinated decision making in distributed systems. *Hum. Factors* **2010**, *52*, 173–188. [CrossRef] [PubMed]
21. Miller, A.; Weinger, M.B.; Buerhaus, P.; Dietrich, M.S. Care coordination in intensive care units: Comminication across information spaces. *Hum. Factors* **2010**, *52*, 147–161. [CrossRef] [PubMed]
22. Desai, V.M.; Roberts, K.P.; Ciavarelli, A.P. The relationship between safety climate and recent accidents: Behavioral learning and cognitive attributions. *Hum. Factors* **2006**, *48*, 639–650. [CrossRef] [PubMed]
23. Stahl, G. Perspective: Group cognition factors in sociotechnical system. *Hum. Factors* **2010**, *52*, 340–343. [CrossRef]
24. Dekker, S. *The Field Guide to Understanding Human Error*; Ashgate: Farnham, UK, 2006.

25. Sargent, S. Communication Errors: A Leading Cause of Mistakes in Healthcare, SE Health Care. Available online: https://www.sehealthcarequalityconsulting.com/2017/09/05/communication-errors-a-leading-cause-of-mistakes-in-healthcare/ (accessed on 10 February 2021).
26. Molesworth, B.R.C.; DEstival, D. Miscommunication in general aviation: The influence of external factors on communication errors. *Saf. Sci.* **2015**, *73*, 73–79. [CrossRef]
27. Swift, M. The Impact of Poor Communication on Medical Errors, The Doctor Weights. Available online: https://thedoctorweighsin.com/impact-poor-communication-on-medical-errors/ (accessed on 10 February 2021).
28. Wilson, D. Failure to Communicate, Safety Foundation. 2016. Available online: https://flightsafety.org/asw-article/failure-to-communicate/ (accessed on 10 February 2021).
29. Tanino, K.; Sakamoto, S.; Aoki, D.; Horishita, T. Study on causes of communication errors. *JR West Saf. Res. Center Rep.* **2018**, *11*, 14–15. (In Japanese)
30. Omino, K. Incident reports submitted by pilots and air traffic controllers. *Railw. Tech. Res. Inst. Rep.* **2017**, *31*, 1–4. (In Japanese)
31. Antonsen, S. *Safety Culture: Theory, Method, and Improvement*; Ashgate: Farnham, UK, 2009.
32. BBC News: Japan's Train Crash: Your Reaction. 2005. Available online: http://news.bbc.co.uk/2/hi/talking_point/4481721.stm (accessed on 10 February 2021).
33. Railway Gazett: Competitive PRESSURE MAY LIE BEHIND AMAGASAKI CRASH. 2005. Available online: https://www.railwaygazette.com/news/single-view/view/competitive-pressure-may-lie-behind-amagasaki-crash.html (accessed on 14 March 2021).
34. JR West: An Overview of the Derailment Accident on the Fukuchiyama Line. 2005. Available online: https://www.westjr.co.jp/global/en/fukuchiyama/outline/ (accessed on 14 March 2021).
35. Mainichi Japan (1): Crack in Shinkansen Bullet Train Undercarriage Could Have Led to Derailment. 2017. Available online: https://mainichi.jp/english/articles/20171220/p2a/00m/0na/019000c (accessed on 14 March 2021).
36. Mainichi Japan (2): Shinkansen's First 'Serious Incident' Shows Operators' Lacking Sense of Crisis. 2017. Available online: https://mainichi.jp/english/articles/20171215/p2a/00m/0na/017000c (accessed on 21 March 2021).
37. The Japan Times: Shinkansen Halted in Nagoya After Oil Leak and Cracked Frame Found. 2017. Available online: https://www.japantimes.co.jp/news/2017/12/13/national/shinkansen-halted-nagoya-serious-incident-oil-leak-frame-crack-found/#.XIqN-LkUkcA (accessed on 21 March 2021).
38. Nikken Asian Review: Crossed Signals Risked Putting Bullet Train on Fast Track to Tragedy. 2017. Available online: https://asia.nikkei.com/Business/Crossed-signals-risked-putting-bullet-train-on-fast-track-to-tragedy (accessed on 21 March 2021).
39. Kyodo News: Shinkansen Bullet Train Kills Intruder on Tracks, Gov't Orders Probe. 2018. Available online: https://english.kyodonews.net/news/2018/06/e69218fd9797-govt-orders-jr-west-to-probe-fatal-incident-involving-bullet-train.html (accessed on 14 March 2021).
40. The Asahi Shimbun: Shinkansen Kept Running with Human Body Parts in Nose. 2018. Available online: http://www.asahi.com/ajw/articles/AJ201806150042.html (accessed on 1 March 2021).
41. Syed, M. *Black Box Thinking: Marginal Gains and the Secrets of High Performance*; John Murray Publishers Ltd.: New York, NY, USA, 2016.
42. Dekker, S. *Just Culture-Balancing Safety and Accountability*; CRC Press: Boca Raton, FL, USA, 2015.
43. Murata, A. Cultural aspects as a root cause of organizational failure in risk ad crisis management in the Fukushima Daiichi disaster. *Saf. Sci.* **2021**, *135*, 105091. [CrossRef]
44. Murata, A.; Karwowski, W. On the root cause of the Fukushima Daiichi disaster from the perspective of high complexity and tight coupling in large-scale systems. *Symmetry* **2021**, *13*, 414. [CrossRef]
45. Antonsen, S.; Ramstad, L.S.; Kongsvik, T. Unlocking the organization: Action research as a means of improving organization safety. *Saf. Sci. Monit.* **2007**, *11*, 1–10.
46. Antonsen, S. The relationship between culture and safety on offshore supply vessels. *Saf. Sci.* **2009**, *47*, 1118–1128. [CrossRef]
47. Edmondson, A.C. Learning from mistakes is easier than done-Group and organizational influences on the detection and correction of human error. *J. Appl. Behav. Sci.* **1996**, *32*, 5–32. [CrossRef]
48. Edmondson, A.C. 1999. Psychological safety and learning behavior in work teams. *Adm. Sci. Q.* **1999**, *44*, 350–383. [CrossRef]
49. Edmondson, A.C. *The Fearless Organization: Creating Psychological Safety in the Workplace for Learning, Innovation, and Growth*; Wiley: Hoboken, NJ, USA, 2018.
50. Weick, K.E. Organization culture as a source of high reliability. *Calif. Manag. Rev.* **1987**, *29*, 112–127. [CrossRef]
51. Radecki, D.; Hul, R.; McCusker, J.; Ancona, C. *Psychological Safety-The Key to Happy, High-Performing People and Teams*; Academy of Brain-based Leadership: Rancho Santa Margarita, CA, USA, 2018.
52. Roberts, K.H.; Rousseau, D.M. Research in nearly failure-free, high-reliability organizations: Having the bubble. *IEEE Trans. Eng. Manag.* **1989**, *36*, 132–139. [CrossRef]
53. Turner, B.; Pidgeon, N. *Ma-Made Disaster*; Wykeham Science Press: London, UK, 1997.
54. Pidgeon, N. In Retrospect: Normal Accidents. *Nature* **2011**, *477*, 404–405. [CrossRef]
55. Pidgeon, N. Complex Organizational Failures-Culture, High Reliability, and Lessons from Fukushima. *Bridge* **2012**, *42*, 17–22.
56. Antonsen, S. Safety culture and the issue of power. *Saf. Sci.* **2009**, *47*, 183–191. [CrossRef]
57. Alvesson, M. *Understanding Organizational Culture*; Sage: London, UK, 2002.