September 28, 2018
Kawasaki Heavy Industries, Ltd.

Regarding the Defects during Manufacturing Process of Series N700 Shinkansen Train Bogie Frames (Part I)

With reference to the crack[1] (structural failure) of the bogie (or truck) frame (hereinafter referred to as the "Failed Bogie Frame") of series N700 Shinkansen train owned by West Japan Railway Company (hereinafter referred as "JR West") occurred at Nagoya Station on 11 December 2017, we, as the manufacturer of the Failed Bogie Frame, hereby express our sincere apology for inconvenience and concern caused to passengers of Tokaido-Sanyo Shinkansen, JR West, Central Japan Railway Company, and any other related party.

With regard to the defects during manufacturing process (see Attachment ①) reported in our news release "Notice of Series N700 Shinkansen Train Bogie Frames matter" on 28 February 2018, we established the Companywide Quality Control Committee in April 2018, including the external experts, and through analysis and guidance using quality control and management methodologies, identified the root causes of the defects and corrective measures to be taken by the Rolling Stock Company[2] in order to prevent recurrence of any similar defect. We hereby report the results of this process (see Part II for details).

We have been involved in the rolling stock business for 110 years. Over the course of that history, we have established the production system that can meet various needs of the customers both in Japan and overseas, including high speed trains, commuter trains, and automated guided transit systems. We therein have elaborated the manufacturing processes based on the experience and expertise of skilled technicians, and transferred such experience and expertise to younger technicians and made improvements such as tightening inspections in each manufacturing process. Nevertheless, in certain aspects, we have relied on discretions or judgments of the manufacturing lines and the skilled technicians in excessive manner.

The results of the investigation conducted by the Companywide Quality Control Committee have revealed that the actions and judgments that caused the defects and the root causes which lead to those actions and judgments, were : vulnerabilities in the quality control and management owing to **excessive reliance on the manufacturing lines** when the manufacturing process of series N700 Shinkansen train began in 2007; and **insufficient risk management to prevent defects** when the supplier for the pressing of the side frames (see Attachment ① Diagram 1) was changed in 2006.

At this juncture, we take the investigation results seriously, and will focus our actions on the following four points as corrective measures for quality management to prevent recurrence:

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1 <Crack> A flaw or fissure that has developed further and become larger as a result of fatigue.

2 <Rolling Stock Company> The company responsible for the rail car business, among the companies in the six fields in which Kawasaki Heavy Industries, Ltd. is developing its business (Ship & Offshore Structure, Rolling Stock, Aerospace Systems, Energy System & Plant Engineering, Motorcycle & Engine, and Precision Machinery & Robot).

① In order to remove excessive reliance on the manufacturing lines and the technicians therein, we will develop a system whereby the related departments can share information on the key points in designs that are critical for ensuring quality of products, thoroughly introduce the KPS[3], which will facilitate to reveal issues by standardizing and visualizing the manufacturing process, and review work processes.
② In order to prevent manufacturing defect, in addition to review of work processes, we will thoroughly control changes in design, manufacturing, and other processes, identify any potential issue that might occur, and tighten the risk management.
③ In order to remove excessive reliance on the manufacturing lines and the technicians therein and tighten the risk management, we will promote close cooperation and communication between the related departments.
④ We will review the internal education and training curriculum including quality, safety, and so on, and enhance the contents of the curriculum.

With regard to bogie frames for Shinkansen trains and conventional trains in Japan and overseas other than the series N700 Shinkansen train, construction shape, and manufacturing method of those bogie frames are different from the ones of the series N700 Shinkansen train, and we have reconfirmed that the manufacturing process in the Manufacturing Department conformed to the work procedures and the drawings. In addition, since the incident of the Failed Bogie Frame, we have reviewed the inspection checking method in the inspection process for the first product (or the first train), and have included arears which cannot be assessable for inspection after completion of manufacturing, to inspection items.

In addition, the Companywide Quality Control Committee is currently conducting comprehensive audits of the entire quality management system in all business units. Our group places "providing safe products and services of superior performance and quality for people all around the world" among its management principles, and, since regular audits of the quality management system are extremely effective to enhance and maintain the level of quality control and management, we will continue to audit the quality management system once a year, and thereby tighten the quality management system of the entire group across the board, and strive to provide products and services that can be used without any concern.

The detailed investigation of the Failed Bogie Frame is still ongoing under the supervision of the Japan Transport Safety Board to identify a root cause and a propagation mechanism of the crack. We will cooperate in the investigation on every level and will continue to dedicate our utmost effort.

End.

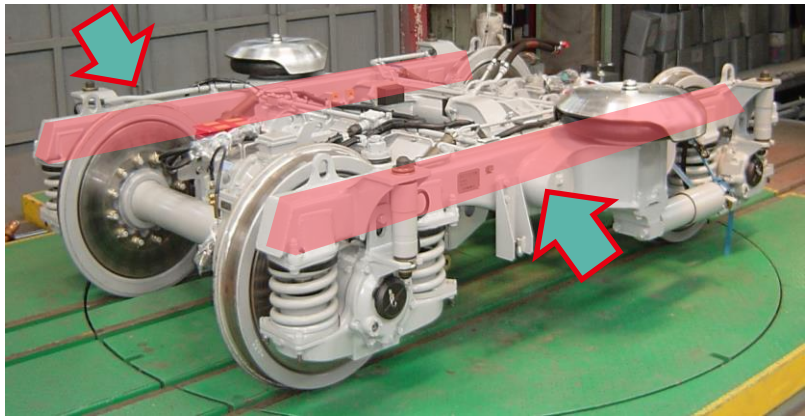
3<KPS (Kawasaki Production System)> A set of production control techniques that are unique to Kawasaki Heavy Industries, Ltd. Their aim is to establish the following, so that consistent quality can be ensured: standardized work practices in order to ensure that the same quality can be achieved whoever does the work; and workplace rules to ensure that these practices are adhered to.

(Attachment ①)

Notice of Series N700 Shinkansen Train Bogie Frames matter (released on 28 February, 2018) 1/2

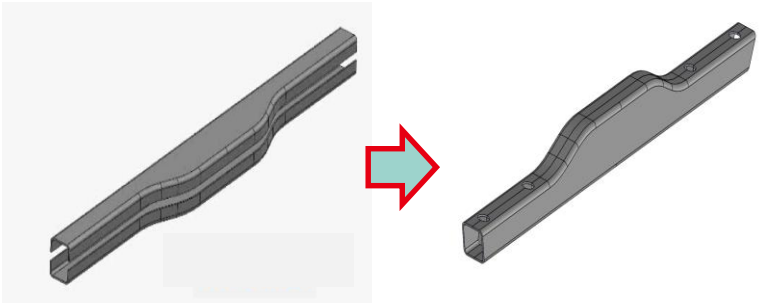
According to the design specifications, the bottom plate of the side frame of the bogie frame (Diagram 1) of series N700 Shinkansen train should be 8mm (more than 7mm post-processing). However, in the Failed Bogie Frame manufactured in February 2007, the thickness of the bottom plate was 4.7mm at the thinnest location. The result of our internal investigation reveal that in order to adjust the gap between the side frame and the primary spring seat (Diagram 4②) during the welding assembly, the uneven bottom plate of the side frame (Diagram 4①) was excessively ground off, resulting in thinner 7mm.
Furthermore, traces of having performed deposit welding* (Diagram 4③) were found across the entire surface of the primary spring seat close to the crack. Although, if such deposit welding was performed, the area should undergo a process reliving residual stress, no record of performance of stress relief process is discovered.

* Deposit welding: A common procedure used to compensate for grinding down and repair dimensional adjustment.



Side frames are one of the key components of a bogie which support the cardoby and transfer tractive and braking efforts to the carbody.

Diagram 1: Bogie Side Frames



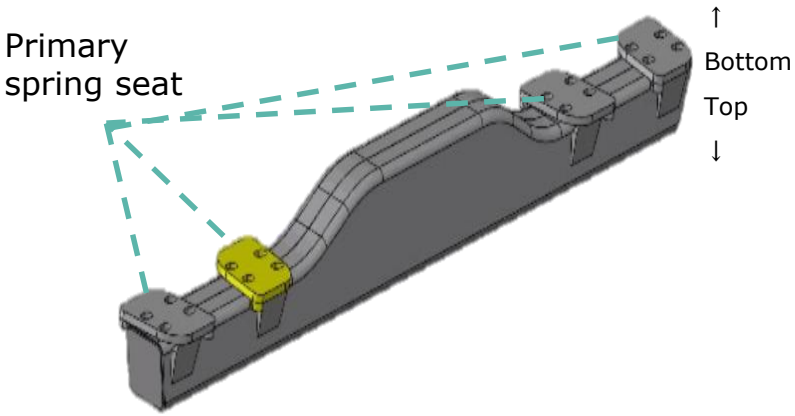
Fabricate two pieces by welding

Fabricate two U-shaped pressed pieces of side frame by welding.

Diagram 2: Welding Fabrication of Side Frames

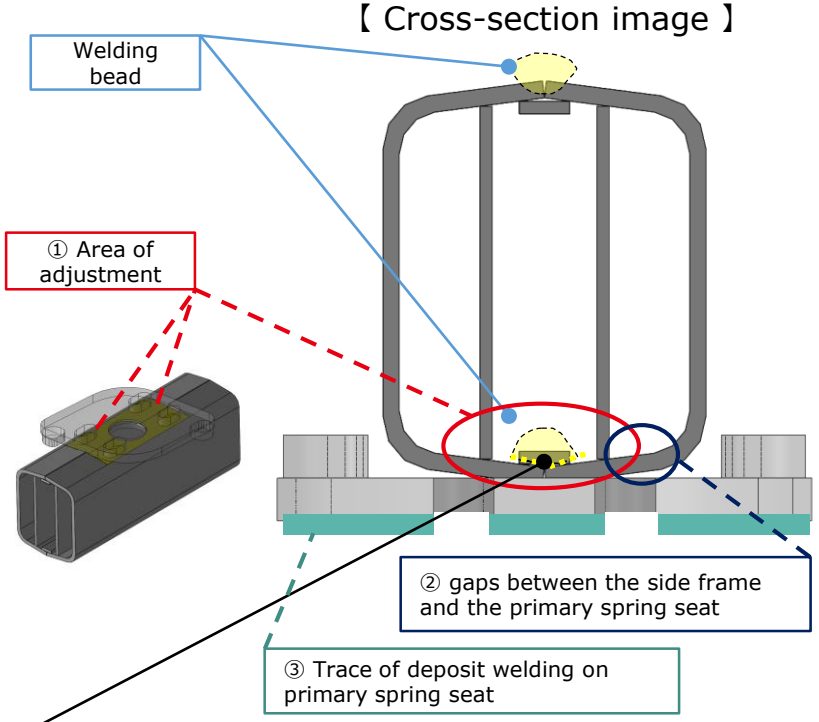
(Attachment ①)

Notice of Series N700 Shinkansen Train Bogie Frames matter (released on 28 February, 2018) 2/2



Four primary spring seats are welded onto one side frame, and there are a total of eight primary spring seats on one bogie.

Diagram 3: Welding Attachment of Parts to Side Frames



When the primary spring seats were attached, the bottom plate of side frame was not even and was ground off to adjust the gaps between the side frame and the primary spring seat to 0.5mm.

Diagram 4: Defects in Adjustment Work during Attachment of Parts to Side Frame

September 28, 2018
Kawasaki Heavy Industries, Ltd.

Regarding the Defects during Manufacturing Process of Series N700 Shinkansen Train Bogie Frames (Part 2: Investigation Results and Corrective Measures)

With regard to the defects during manufacturing process reported in our news release "Notice of Series N700 Shinkansen Train Bogie Frames matter" on 28 February 2018, we hereby report the root causes of the defects which have been investigated and examined by the Companywide Quality Control Committee (hereinafter referred to as the "Committee") established in April 2018, and the corrective measures that will be taken by us in order to prevent recurrence.

1. Investigation results by the Committee

(1) Background to and purpose of establishment

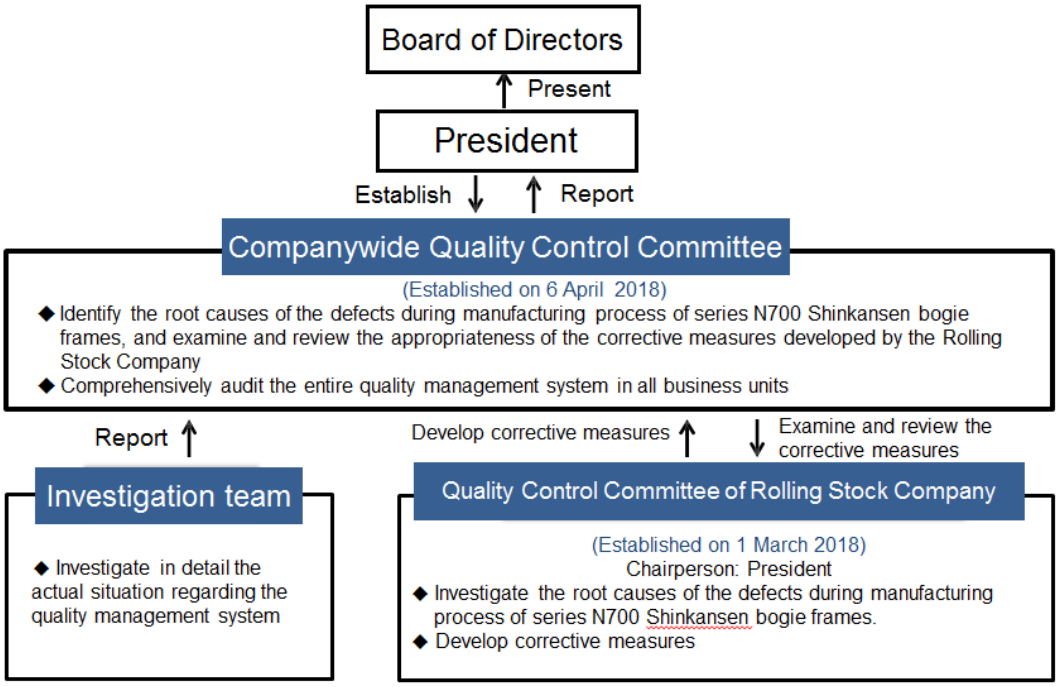
In February 2018, the defects during manufacturing process of series N700 Shinkansen bogie frames were revealed in the Rolling Stock Company[1]. Consequently, the President established the Committee on 6 April 2018 as an internal committee to identify the root causes and examine corrective measures to prevent recurrence. The details of the investigation and examination by the Committee are as follows;

- Root causes of the defects during manufacturing process;
- Appropriateness of the corrective measures developed by the Quality Control Committee of the Rolling Stock Company with regard to the above root causes; and
- Results of comprehensive audits of the entire quality management system in all business units (currently underway)

In addition, an investigation team was established as an organization under the Committee to investigate in detail the actual situation regarding the quality management system and report the investigation results to the Committee.
Having received the results of the examination by the Committee, the President presented the corrective measures for preventing recurrence to the Board of Directors and the Board of Directors endorsed such corrective measures. Furthermore, the implementation of the corrective measures in the Rolling Stock Company will be regularly monitored at the Management Committee, and will be supervised by the Board of Directors.
The function of the Committees and the correlation between them are as shown in Diagram ①.

[1] <Rolling Stock Company> The company responsible for the rail car business, among the companies in the six fields in which Kawasaki Heavy Industries, Ltd. is developing its business (Ship & Offshore Structure, Rolling Stock, Aerospace Systems, Energy System & Plant Engineering, Motorcycle & Engine, and Precision Machinery & Robot).

Diagram ①: Function of and correlation



(2) Particulars of the Committee

The Committee is composed of 10 members, including experts on quality management, lawyers, and directors.

Chairperson	Takeshi Nakajo	Professor at the Department of Industrial and System Engineering, Chuo University
Members	Hiroshi Osada	Professor Emeritus at Tokyo Institute of Technology
	Masahiko Munechika	Professor at the Department of Industrial & Management System Engineering, Waseda University
	Toshiaki Yamaguchi	Lawyer
	Yoshihiko Morita	Outside Director (until June 27, 2018)
	Michio Yoneda	Outside Director
	Yoshiaki Tamura	Outside Director (effective June 27, 2018)
	Munenori Ishikawa	Representative Director, Vice President and Senior Executive Officer
	Kenji Tomida	Representative Director, Vice President and Senior Executive Officer
	Ikuhiro Narimatsu	Managing Executive Officer
	Shinji Koga	Fellow, Corporate Technology Division

The investigation team is composed of 6 members, including quality management consultants and internal experts on quality management.

Members	Yoshito Hirabayashi	Chairman, Technofer Ltd.
	Munenori Ishikawa	Representative Director, Vice President and Senior Executive Officer
	Shinji Koga	Fellow, Corporate Technology Division
	Chiharu Shoji	Vice General Manager, QM Promoting Division, Aerospace Systems Company
	Hideo Marui	Senior Manager, Quality Assurance Division, Precision Machinery Business Division, Precision Machinery & Robot Company
	Yoshiki Hashimoto	Senior Manager, Quality Technology Department, Kawasaki Naval Engine Service, Ltd.

(3) Details of main activities

Two defects during manufacturing process have been discovered: ① grinding off of the bottom plates of the side frames[2]; and ② provability that the residual stress was not relived by annealing or some other process after the entire bottom surface of the primary spring seat[3] was treated with deposit welding[4]. Defect ② was only found at the primary spring seat close to the crack of the Failed Bogie Frame, and although tracing of its work records and interviews with the manufacturing staff were conducted, it was not confirmed how and why the deposit welding was performed. Therefore, analysis of the root causes was only conducted for ① because both ① and ② occurred at the same bogie frame manufacturing shop and it was judged that the corrective measures against the issues and the root causes pertaining to ① above could prevent recurrence of manufacturing defects.

The Committee held seven meetings as shown in the table below, and reviewed the following three issues: a) the actions/judgments that led to the manufacturing defects; b) the root causes of the actions/judgments that led to the manufacturing defects; and c) corrective measures for preventing recurrence of the root causes.

Regarding the above a), the actions and judgments of the related departments were traced since the new subcontractor was engaged for pressing of the side frames in 2004 up to the occurrence of the manufacturing defects in 2007. The method employed was Variation Tree Analysis[5] (hereinafter referred to as "VTA"), which is generally used to identify human and organizational actions/judgments that have caused defects.

As a result of the analysis, four actions/judgments in the multiple departments, including Design, Purchasing, Manufacturing, and Quality Assurance, were identified as having led to the manufacturing defects.

Next, the four actions/judgments that led to the manufacturing defects were each pursued further through 5 Whys Analysis[6], to locate where the causes that brought them about were in the systems/activities of the organization. Furthermore, the situation regarding quality management system in the Rolling Stock Company was assessed, and, integrating the results of this assessment and the results of the 5 Whys Analysis, the root causes that needed to be corrected were narrowed down.

Finally, the appropriateness of the proposed corrective measures developed by the Quality Control Committee of the Rolling Stock Company with regard to the narrowed-down root causes was examined.

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2 See Diagram 1 in Part I, Attachment ①

3 See Diagram 3 in Part I, Attachment ①

4 <Deposit welding> Deposit welding: A common procedure used to compensate for grinding off and repair dimensional adjustment.

5 <Variation Tree Analysis (VTA)> An analysis method that goes through the process that led up to the occurrence of a defect with the emphasis on human actions and judgments. It assumes there is tree-like branching in a time series, and is used to identify the "branch points" of the actions or judgments that caused the defect to occur.

6 <5 Whys Analysis> A method which aims to ultimately reach the fundamental cause (root cause) of a problem, by presenting a factor (a "why") which caused the problem, then presenting a factor (a "why") which caused that factor, and repeating this process five times.

The dates of and main issues examined in the Committee meetings are as follows.

Session	Date	Main matters examined
1	25 April 2018	- Results of the investigations into the root causes (VTA, 5 Whys Analysis) - Results of the quality management level assessment
2	16 May 2018	- Results of additional investigations into the root causes - Results of additional investigations conducted by means of shop investigation - Correlation between the root causes and the assessment of the quality management level
3	29 May 2018	- Results of additional investigations into the root causes - Correlation between the root causes and the assessment of the quality management level
4	19 June 2018	- Results of additional investigations into the root causes - Examination of the proposed corrective measures for quality management system
5	11 July 2018	- Reporting of the results of additional investigations into the root causes - Examination of the proposed corrective measures for quality management system - Examination of the plans for investigating the quality management system in all business units
6	6 August 2018	- Examination of the proposed corrective measures for quality management system
7	28 August 2018	- Examination of the proposed corrective measures for quality management system

(4) Investigation results: The actions/judgments that led to the manufacturing defects, and their root causes

The four actions/judgments and their root causes that led to the manufacturing defects as identified through the investigations, are as follows (shown in chronological orders). The root causes that are common to all of the four actions/judgments are summarized in E.

A) Control of changes (June 2006)

Since the subcontracter to previously perform the pressing for the side frames discontinued manufacturing of components for rolling stock, another subcontractor was engaged for the pressing for the side frames for series N700 Shinkansen bogie frames and the processing methods were also changed. Although the implications of those changes were predictable, the related departments did not jointly reviewed or assessed such implications of the changes.

<Root Causes>

① The rules allowed the Purchasing Department to have its sole discretion about the necessity of discussing the matters in-house.

② Analysis of past issues that had resulted from changes had not been conducted sufficiently.

B) Preliminary verification (October 2006)

Meetings were held for the purpose of preventing issues in the manufacturing processes of series N700 Shinkansen bogie frames, but the changes regarding the pressing methods and the subcontractor for the side frames were not discussed. Also, the meetings were not held at appropriate times.

<Root Causes>

① The way to organize the meeting for ensuring the quality of products had not been sufficiently reviewed in the Rolling Stock Company.

② The timing when the meetings for the purpose of preventing occurrence of issues were not clearly defined.

③ The importance of reviewing the past track record, predicting potential issues in advance, and taking preventive measures was not sufficiently recognized.

C) Share of technical information from the design departments to the manufacturing shop (January 2007)

Although the work guidelines[7] regarding "control of gaps between the side frame and the primary spring seat" had been issued in accordance with the internal rules, the staff in the Manufacturing Department did not explain or give instructions regarding contents of the work guidelines to the manufacturing supervisors and technicians prior to commencement of the work.

<Root Causes>

① In the upstream of work processes (where customer requirements/specifications are reflected to the design), the system for identifying the critical design points to be noted and ensuring that those critical design points are transmitted and deployed in the downstream work processes (procurement, manufacturing and quality assurance) was insufficient.

② The work guidelines summarized the key points regarding the work process that the Manufacturing Department knew on the basis of experience, but did not cover all of the critical design points.

[7] <Work guidelines> Materials that supplement the drawings. They are documents that communicate to the workers important notes and points of caution regarding performing the manufacturing work.

D) Management of the manufacturing shop (June 2007)

The technicians in shop assembled the side frames without having been informed of the permissible thickness of grinding off in the vicinity of the welding beads[8] on the side frames. Since the supervisors in shop were not aware that the processing methods for the side frames had been changed and that their dimensional accuracy varied, they assumed that the thickness of grinding off were within the permissible one, and verbally gave instructions to grind off the bottom plates of the side frames without confirming the actual manufacturing situation in shop.

<Root Causes>

① The KPS[9] activities to make abnormal work deviating from the work standards visible had not been implemented enough.

② The purpose/importance of developing work standards (including work guidelines) for all processes and performing manufacturing work in compliance with the work standards was not recognized sufficiently.

③ The Quality Assurance Department had not been given the role of monitoring the manufacturing processes in terms of quality and requesting/suggesting corrective actions where necessary.

E) Root causes common to A to D

The followings are the identified causes that are common to the actions/judgments A to D that caused the manufacturing defects.

① Inter-departments communication was not actively carried out.

② The curriculum of the education on quality control and management provided in the Rolling Stock Company was insufficient, and education for employees was not sufficiently provided for analyzing product safety, the past track record, continuously pursuing quality improvements and the KPS.

On the basis of the investigation results, it was concluded that: from A) and B), there was insufficient risk management to prevent the manufacturing defects when the subcontractor was changed in 2006; from C) and D), there were vulnerabilities regarding quality control and management owing to excessive reliance on the manufacturing shop when the manufacturing of series N700 Shinkansen train started in 2007; and from E), inter-departments communication and education on quality control and management were also causing factors.

[8] <Welding bead> A bulge of welded metal created as a result of fusing a welding rod, etc. at the welding section and building it up.

[9] <KPS (Kawasaki Production System)> A set of production control techniques that are unique to Kawasaki Heavy Industries, Ltd. The aim of the KPS is to establish the standardized work practices in order to achieve the same quality constantly whoever does the work; and shop rules to adhere to the standardized work practices.

2. Corrective measures for preventing recurrence

On the basis of results received from the Committee regarding the examination of the actions/judgments that led to the manufacturing defects and their root causes, the Quality Control Committee of the Rolling Stock Company developed the corrective measures, and the Committee examined the appropriateness such measures. In consideration of the examination result, we have determine to take the following corrective measures. The reference number of the corresponding actions/judgments that led to the manufacturing defects and their root causes is indicated in brackets, and those correlation is as shown in Diagram ②.

(1) Review of the work processes

<Cross-departmental efforts, including the concurrent activities[10]>

- Expand the application of the concurrent activities that are conducted in some projects and whose effectiveness has been proven, in order to strengthen the cross-departmental verification of potential issues. In the concurrent activities, the opinions of the related departments, such as Marketing & Sales, Purchasing, Manufacturing, and Quality Assurance (which is in charge of after-sales service as well), are reflected to the drawings in the design process, and the related departments work together to build in quality from the design stage. Also develop a system of performing verification by the related departments prior to completion of the design drawings.
  (B①, B②)
- In parallel with the concurrent activities, prior to completion of the design drawings, hold design review meetings involving experienced personnel from the related departments (not only the Design Department but also other departments) who have an abundance of knowledge and experience, in order to strengthen the system for predicting potential issues based on the past experience.
  (B①, B②, B③)

<Adherence to adapt the KPS>

- Adhere to adapt the KPS, which was initiated by the motorcycle business unit and has contributed to quality improvements in the aerospace business unit and others. In the KPS, the work processes at the manufacturing shop are broken down to standardized works is set, and a standard work time is set for each standardized work. The standardized work and the corresponding standard work time are shown on the individual production control boards for the manufacturing technicians, and the actual performance record for each standardized work (work content, work time, etc.) is monitored in details. Deployment of the KPS to all manufacturing shops (under deployment to each shops since March 2018) will enable to detect any abnormal work that deviates from the work instructions and immediately take corrective measures. In order to deploy the KPS quickly, promote introduction through guidance by KPS consultants who have successful track records in other companies, and by top-down orders from the executive management staff. (D①)

10 <Concurrent activities> Activities whereby multiple processes in product development are conducted simultaneously in parallel. Design, Development and the other departments in the upstream processes, and Purchasing, Manufacturing, Quality Assurance, After-Sales Service and the other departments in the downstream processes share information, and work together through cross-departmental cooperation to achieve, for example, designs that take into consideration using structures that will be easy to manufacture, and cost-effective product development.

- Develop a manufacturing regime that does not rely on the experience or intuition of manufacturing shops by introduction of the KPS which is primarily based on written work instructions and monitoring of actual performance records. (D②)
- Define internal rules that will enable the Quality Assurance Department to check and monitor whether regular control in the Manufacturing Department is performed appropriately and the operation of the KPS is implemented as planned. Also, provide a system that will enable the Quality Assurance Department to monitor each work process across the board, and revise the internal rules so that process audits (including diagnosis of manufacturing shops) can be performed in addition to the current internal audits. (D③)

<Review of the preparation process prior to manufacturing>

- Together with the concurrent act develop a system to ensure that the results of reviews and verifications performed by the related departments prior to completion of the drawings and are integrated into the documents related to manufacturing.
  (B①, C①, C②, D②)
- Ensure that the critical design points to be noted are reflected in the manufacturing documents such as the work guidelines, and the inspection documents, so that the critical design points can be understood in the downstream processes (procurement, manufacturing, quality assurance).
  (C①, C②, D②)

(2) Strengthening risk management

<Thorough control of changes>

- In order to ensure that the issues discussed between departments are reflected in the handling process of critical changes, make the items to be controlled as changes understandable level to anyone, and categorize the items to be controlled by single department or the items to be discussed and controlled by plural departments. Clearly define those items in the rules and eliminate discretions by individuals. (A①)
- Have the Quality Assurance Department control all the process for controlling changes and follow up on its control until the project is completed. In addition, establish a system for sharing performance record and utilize such performance record for future projects in the Rolling Stock Company. (A①, A②)

<Thorough identification and analysis of issues from review of past manufacturing projects>

- Besides the annual overall review of completed projects, conduct multiple reviews upon each delivery of products of respective projects and define such review opportunities as rules. Have all the related departments participate in the review, analyze the issues, discuss the corrective measures, and keep records of the reviews for future projects.
  (A②, B①, B②, B③)

- Provide opportunities to comprehend information on the after-sales service such as the teething issues and claims after delivery of the first car (or the first train), and utilized such information for improvement of the quality management system.
  (A②, B①, B②, B③)

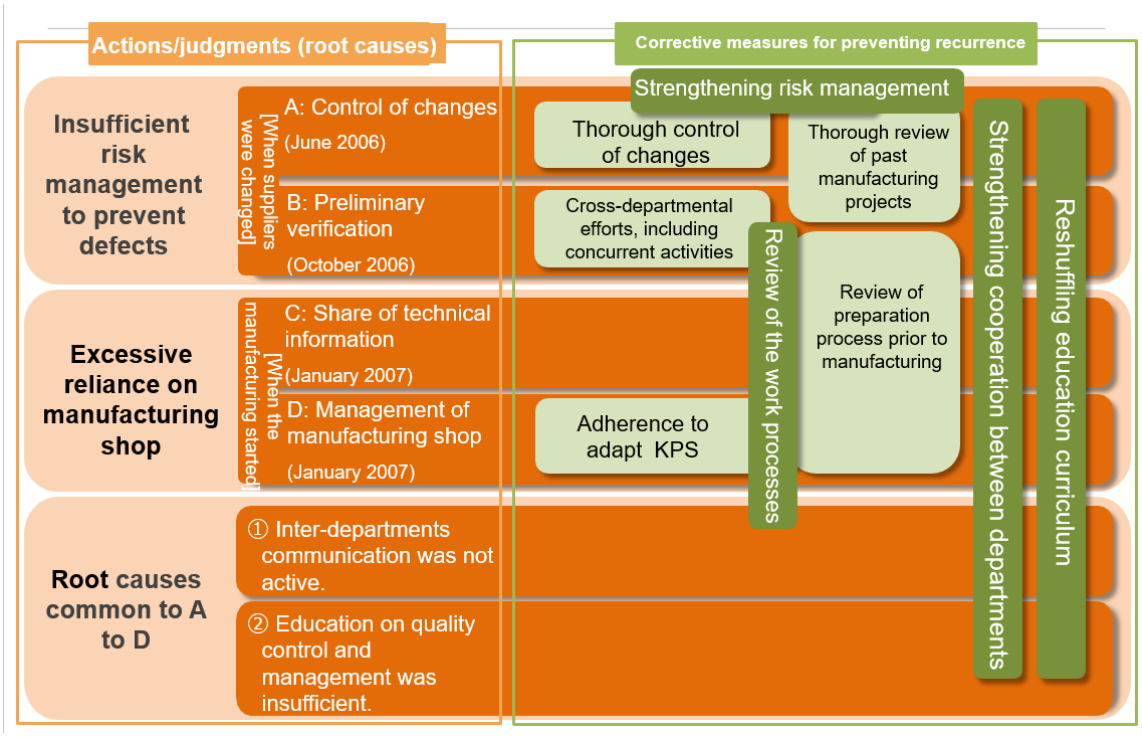
(3) Strengthening cooperation between departments

- Review the system for company-level policy control, and provide an additional system for planning and executing key corrective measures across departments in addition to the existing achievement management in each department.(E①)
- In order to promote communication between departments, have teams consisting of plural concerned persons discuss and find solutions regarding, for example, ways to cooperate between departments in the company and mutual understanding between departments regardless of concerns of each department, and expand such teaming works. (E①)

(4) Reshuffling the education curriculum

- Add to the existing education curriculum in the company more contents regarding the insufficient areas, such as product safety, risk management, analysis of past manufacturing projects, and preliminary verification, and have the dedicated departments including Quality Assurance, Design, and Manufacturing, review the education curriculum across departments. (E②)
- Enhance the human resources skills map, comprehend the level of work performance on each organization basis, utilize such information for organizational management, and reshuffle the education curriculum to correspond to the targets for human resources development. (E②)

Diagram ②: Correlation between the actions/judgments that led to the manufacturing defects and their root causes, and the corrective measures for preventing recurrence



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Regarding the Defects during Manufacturing Process of Series N700 Shinkansen Train Bogie Frames

(Part 2: Investigation Results and Corrective Measures) Explanatory Material

September 28, 2018

Kawasaki Heavy Industries, Ltd.

Kawasaki

Powering your potential

1. Investigation Results by Companywide Quality Control Committee

(1) Background to and purpose of establishment

■In February 2018, the defects during manufacturing process of series N700 Shinkansen bogie frames were revealed in the Rolling Stock Company[*1]. Consequently, the President established the Committee on April 6, 2018 as an internal committee to identify the root causes and examine corrective measures to prevent recurrence. The details of the investigation and examination by the Committee are as follows;

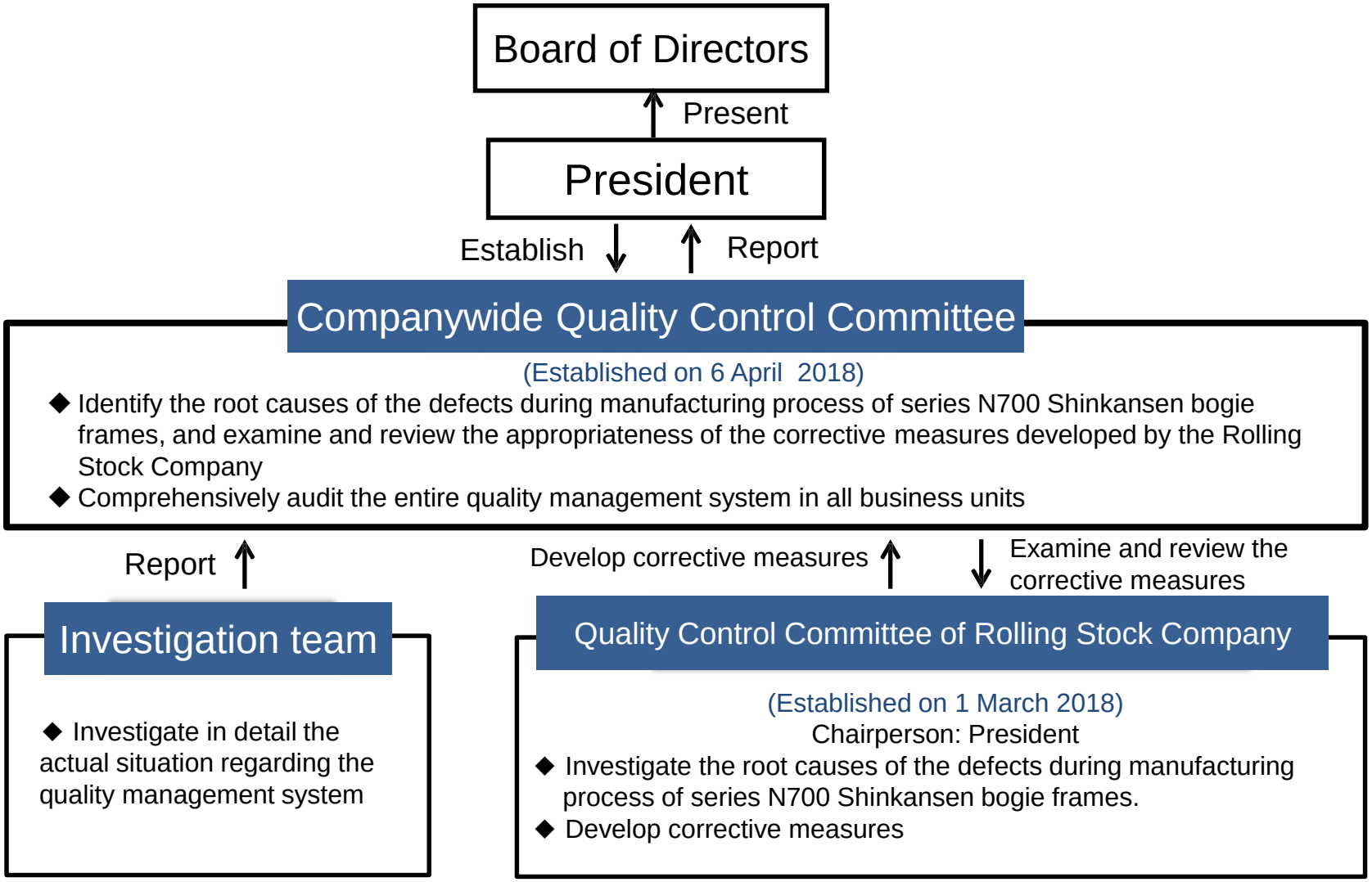
- Root causes of the defects during manufacturing process
- Appropriateness of the corrective measures developed by the Quality Control Committee of the Rolling Stock Company with regard to the above root causes
- Results of comprehensive audit of the entire quality management system in all business units (currently underway)

■An investigation team was established as an organization under the Committee to investigate in detail the actual situation regarding the quality management system and report the investigation results to the Committee.

■Having received the results of the examination by the Committee, the President presented the corrective measures for preventing recurrence to the Board of Directors and the Board of Directors endorsed such corrective measures. Furthermore, the implementation of the corrective measures in the Rolling Stock Company will be regularly monitored at the Companywide Management Meeting, and will be supervised by the Board of Directors.

1. Investigation Results by Companywide Quality Control Committee

Diagram ①: Function of and correlation between Committees



1. Investigation Results by Companywide Quality Control Committee

(2) Particulars of Companywide Quality Control Committee

	Name	Designation
Chairperson	Takeshi Nakajo	Professor at the Department of Industrial and System Engineering, Chuo University
Members	Hiroshi Osada	Professor emeritus at Tokyo Institute of Technology
	Masahiko Munechika	Professor at the Department of Industrial & Management System Engineering, Waseda University
	Toshiaki Yamaguchi	Lawyer
	Yoshihiko Morita	Outside Director (until 27 June 2018)
	Michio Yoneda	Outside Director
	Yoshiaki Tamura	Outside Director (effective 27 June 27 2018)
	Munenori Ishikawa	Representative Director, Vice President and Senior Executive Officer
	Kenji Tomida	Representative Director, Vice President and Senior Executive Officer
	Ikuhiro Narimatsu	Managing Executive Officer
	Shinji Koga	Fellow, Corporate Technology Division

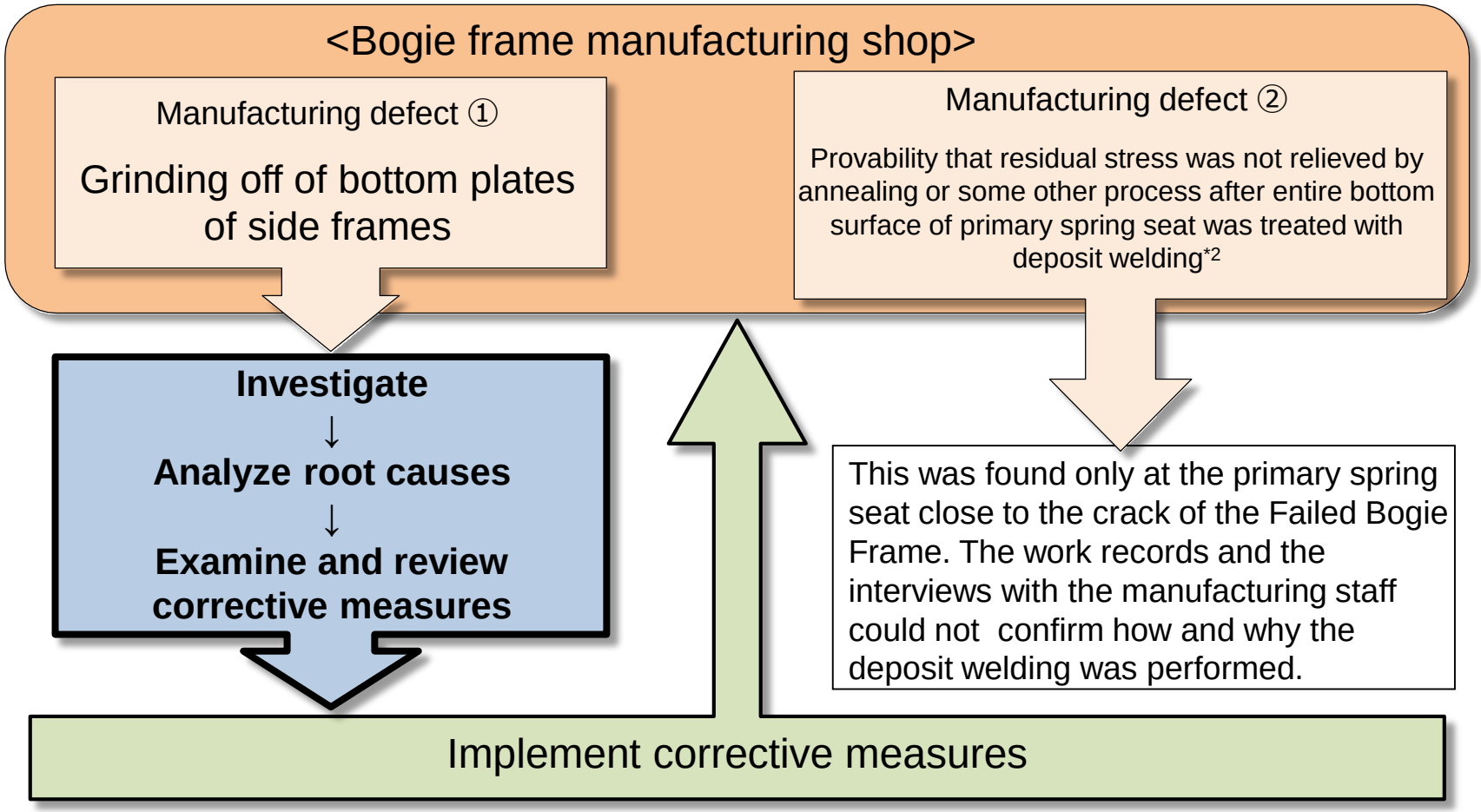
1. Investigation Results by Companywide Quality Control Committee

(2) Particulars of Investigation Team

	Name	Designation
Members	Yoshito Hirabayashi	Chairman, Technofer Ltd.
	Munenori Ishikawa	Representative Director, Vice President and Senior Executive Officer
	Shinji Koga	Fellow, Corporate Technology Division
	Chiharu Shoji	Vice General Manager, QM Promoting Division, Aerospace Systems Company
	Hideo Marui	Senior Manager, Quality Assurance Division, Precision Machinery Division, Precision Machinery & Robot Company
	Yoshiki Hashimoto	Senior Manager, Quality Technology Department, Kawasaki Naval Engine Service, Ltd.

1. Investigation Results by Companywide Quality Control Committee

(3) Details of main activities



It was judged that the corrective measures against the issues and the root causes pertaining to ① above could prevent recurrence of manufacturing defects including ②, because both ① and ② occurred at the same manufacturing shop.

1. Investigation Results by Companywide Quality Control Committee

(3) Details of main activities

Details deliberated in the Committee meetings (7 sessions in total)

a) Actions/judgments that led to the manufacturing defects

- Traced the actions and judgments by the related departments, since the new subcontractor was engaged for pressing of the side frames in 2004 up to the occurrence of the manufacturing defects in 2007. The method employed was Variation Tree Analysis*3.

→ **Identified that four actions/judgments in multiple departments, including Design, Purchasing, Manufacturing, and Quality Assurance, led to the manufacturing defects.**

b) Root causes of the actions/judgments that led to the manufacturing defects

- Further pursued the causes of the four actions/judgments that led to the manufacturing defects through 5 Whys Analysis*4, to locate where the root causes that brought them about were in the systems/activities of the organization.
- Assessed the situation regarding implementation of quality management system in the Rolling Stock Company.

→ **Integrated the results of assessing the situation regarding implementation of quality management system and the results of 5 Whys Analysis, and narrowed down the root causes to be corrected.**

C) Corrective measures for preventing recurrence

Examined appropriateness of the corrective measures to the root causes.

1. Investigation Results by Companywide Quality Control Committee

(3) Details of main activities

Session	Date	Main matters examined
1	25 April 2018	- Results of the investigation into the root causes (Variation Tree Analysis, 5 Whys Analysis) - Results of the quality management level assessment
2	16 May 2018	- Results of additional investigations into the root causes - Results of additional investigations conducted by means of shop investigation - Correlation between the causes and the assessment of the quality management level
3	29 May 2018	- Results of additional investigations into the root causes - Correlation between the root causes and the assessment of the quality management level
4	19 June 2018	- Results of additional investigations into the root causes - Examination of the proposed corrective measures for quality management system
5	11 July 2018	- Reporting of the results of additional investigations into the root causes - Examination of the proposed corrective measures for quality management system - Examination of the plans for investigating the quality management in all business units
6	6 August 2018	- Examination of the proposed corrective measures for quality management system
7	28 August 2018	- Examination of the proposed corrective measures for quality management system

1. Investigation Results by Companywide Quality Control Committee

(4) Investigation results: The actions/judgments that led to the manufacturing defects, and their root causes

A) Control of changes (June 2006)

Actions/judgments	
When the supplier for the pressing of the side frames and the pressing method were changed during the preparation stage for manufacturing series N700 Shinkansen bogie frames, **- The implications of the above changes were predictable, but were not reviewed or assessed by the related departments jointly.**	
Root causes	
A①	**- The rules allowed the Purchasing Department to have its sole discretion about the necessity of discussing the matters in-house.**
A②	**- Analysis of past issues that had resulted from changes had not been conducted sufficiently.**

1. Investigation Results by Companywide Quality Control Committee

(4) Investigation results: The actions/judgments that led to the manufacturing defects, and their root causes

B) Preliminary verification (October 2006)

Actions/judgments
In the meetings for the purpose of preventing issues in the manufacturing processes, **- The changes regarding the pressing methods and suppliers for the side frames were not discussed.** **- The meetings were not held at appropriate times.**

Root causes	
B①	**- The way to organize the meeting for ensuring the quality of products had not been sufficiently reviewed in the Rolling Stock Company.**
B②	**- The timing when the meetings for the purpose of preventing occurrence of issues were not clearly defined.**
B③	**- The importance of reviewing the past track record, predicting potential issues in advance, and taking preventive measures was not sufficiently recognized.**

1. Investigation Results by Companywide Quality Control Committee

(4) Investigation results: The actions/judgments that led to the manufacturing defects, and their root causes

C) Share of technical information from design departments to manufacturing shop (January 2007)

Actions/judgments	
Although the work guidelines*7 regarding "control of gaps between the side frame and the primary spring seat" had been issued in accordance with the internal rules, **- The staff in the Manufacturing Department did not explain or give instructions regarding contents of the work guidelines to the manufacturing supervisors and technicians prior to commencement of the work.**	
Root causes	
C①	**- In the upstream of work processes (where customer requirements/specifications are reflected to the design), the system for identifying the critical design points to be noted and and ensuring that those critical design points are trasmitted and deployed in the downstream work processes (procurement, manufacturing, quality assurance) was insufficient.**
C②	**- The work guidelines did not cover all of the critical design points.**

1. Investigation Results by Cmpanywide Quality Control Committee

(4) Investigation results: The actions/judgments that led to the manufacturing defects, and their root causes

D) Management of manufacturing shop (June 2007)

Actions/judgments	
With regard to the permissible thickness of grinding off in the vicinity of the welding beads[*5] on the side frames, **- The technicians in shop assembled the side frames without having been informed of such permissible thickness.** **- The supervisors in shop** were not aware that the processing methods for the side frames had been changed and their dimensional accuracy varied, and **verbally gave instructions to grind off the bottom plates of the side frames without confirming the actual manufacturing situation in shop.** The supervisors in shop assumed that the thickness of grinding off were within the permissible one.	
Route causes	
D①	**- The KPS[*6] activities to make abnormal work that deviated from the work standards visible had not implemented enough.**
D②	**- The purpose/importance of developing work standards for all processes and performing manufacturing work in compliance with the work standards was not recognized sufficiently.**
D③	**- The Quality Assurance Department had not been given the role of monitoring the manufacturing processes in terms of quality and requesting/suggesting correction where necessary.**

1. Investigation Results by Companywide Quality Control Committee

(4) Investigation results: The actions/judgments that led to the manufacturing defects, and their root causes

E) Root causes common to A to D

Root causes	
E①	**- Inter-departments communication was not actively carried out.**
E②	The curriculum of the education on quality control and management was insufficient, and **- Education for employees was not sufficiently provided for analyzing product safety, the past track record, continuously pursuing quality improvements and the KPS.**

From the investigation results, the following root causes were concluded.
A) and B) → Insufficient risk management to prevent defects when the subcontractor was changed in 2006
C) and D) → Vulnerabilities regarding quality control and management owing to excessive reliance on the manufacturing shop when the manufacturing of series N700 Shinkansen train started in 2007
E) → Inter-departments communication and education on quality control and management

2. Corrective Measures for Preventing Recurrence

(1) Review of work processes

<Cross-departmental efforts, including concurrent activities[*8]>

Corrective measures	Correlation to root causes
- Expand the application of the concurrent activities, in order to strengthen the cross-departmental verification of potential issues. - The related departments, such as Marketing & Sales, Purchasing, Manufacturing, and Quality Assurance, work together to **build in quality from the design stage.** **- Develop a system of performing verification by the related departments prior to completion of the design drawings.**	B①, B②
- Prior to completion of the design drawings, hold design review meetings involving experienced personnel from related departments who have an abundance of knowledge and experience, in order to **strengthen the system for predicting potential issues based on the past experience**.	B①, B②, B③

2. Corrective Measures for Preventing Recurrence

(1) Review of work processes

<Adherence to adopt KPS>

Corrective measures	Correlation to root causes
- Deploying the KPS to all manufacturing shop (under deployment to each shop since March 2018) **will enable to detect abnormal work that deviates from the work instructions and immediately take corrective measures.** **- Promote introduction through guidance by KPS consultants, and by top-down orders from executive management staff**	D①
- **Develop a manufacturing regime that does not rely on the experience or intuition of manufacturing shops**, by introduction of the KPS, which is primarily based on written work instructions and monitoring actual performance records.	D②
- Define internal rules that will enable the Quality Assurance Department **to check and monitor the operation of the KPS is being implemented as planned.** **- Provide a system that will enable the Quality Assurance Department to monitor each work process across the board, and revise the internal rules so that process audits (including diagnosis of manufacturing shop) can be performed in addition to** the current internal audits**.**	D③

2. Corrective Measures for Preventing Recurrence

(1) Review of work processes

<Review of preparation process prior to manufacturing>

Corrective measures	Correlation to root causes
- **Develop a system to ensure that** the results of review and verifications performed by the related departments prior to completion of the drawings and **are integrated into the documents related to manufacturing**.	B①, C①, C②, D②
- **Ensure** that the critical design points to be noted are **reflected in the manufacturing documents, such as the work guidelines, and the inspection documents**, so that the critical design points can be understood in the downstream processes (procurement, manufacturing, quality assurance).	C①, C②, D②

2. Corrective Measures for Preventing Recurrence

(2) Strengthening risk management

<Thorough control of changes>

Corrective measures	Correlation to root causes
- **Make the items to be controlled as changes understandable level**. (Categorize the items to be controlled by single department or to be discussed and controlled by plural departments.) - Clearly define those items in the rules, and **eliminate discretions by individuals.**	A①
- **Have the Quality Assurance Department control the process for controlling changes and follow up on its control.** - **Establish a system for sharing performance record and utilize such performance records for future projects in the Rolling Stock Company.**	A①, A②

2. Corrective Measures for Preventing Recurrence

(2) Strengthening risk management

<Thorough identification and analysis of issues from review of past manufacturing projects>

Corrective measures	Correlation to root causes
- Besides the annual overall review of completed projects, **conduct multiple reviews upon each delivery of products of respective projects.** **-** All the related departments participate, **analyze the issues and discuss the corrective measures, and keep records of the reviews for future projects.**	A②, B①, B②, B③
- **Provide opportunities to comprehend** information on the after-sales service such as the teething issues, **and utilize such information for improvement of the quality management system.**	A②, B①, B②, B③

2. Corrective Measures for Preventing Recurrence

(3) Strengthening cooperation between departments

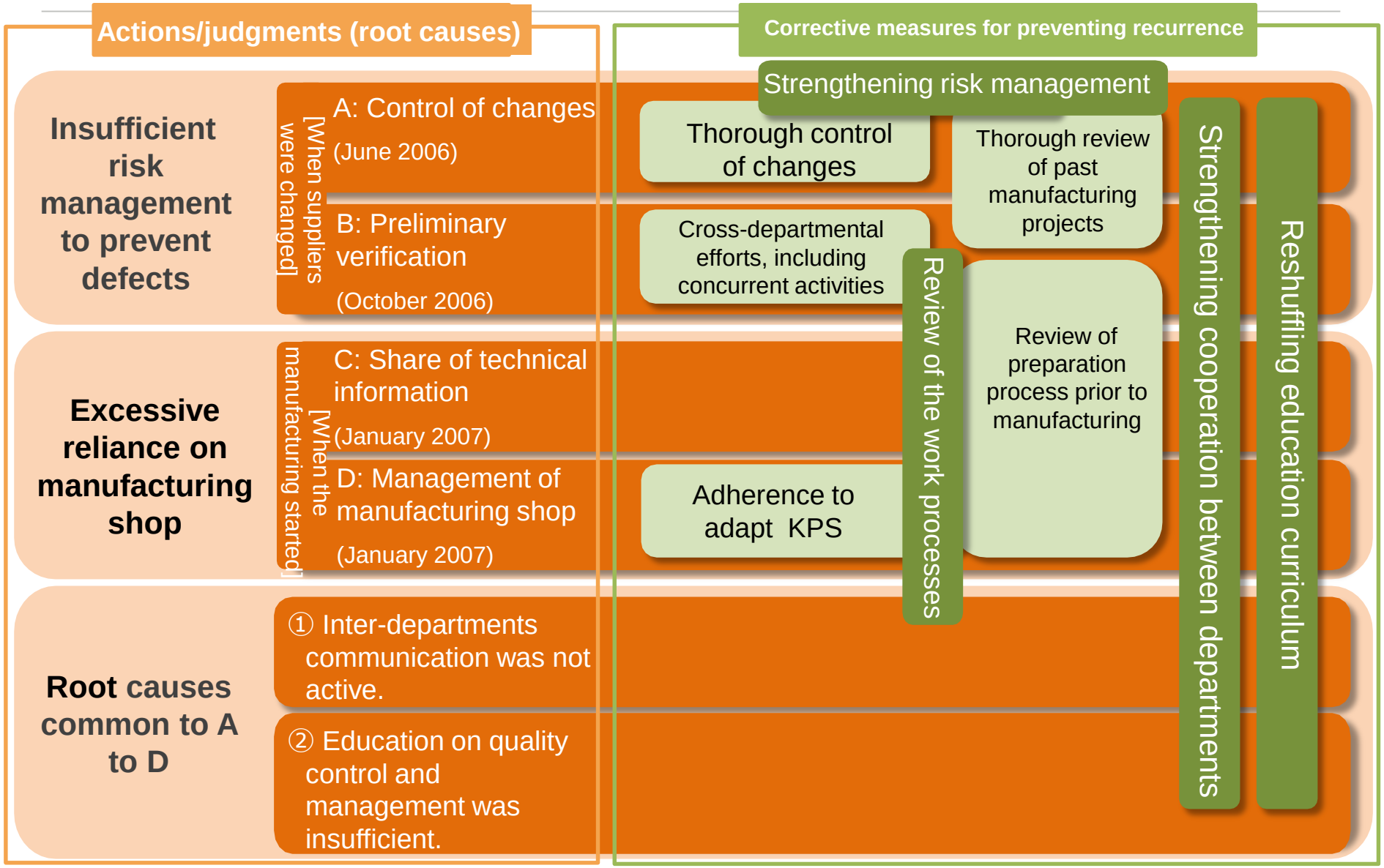
Corrective measures	Correlation to root causes
- Review the system for company-level policy control, and **provide an additional system for planning and executing key corrective measures across departments**, in addition to the existing achievement management in each department.	E①
- In order to promote communication between departments, **have teams consisting of plural concerned persons involved discuss and find solutions** regarding, for example, ways to cooperate between departments in the company and mutual understanding between departments regardless of concerns of each department and expand such teaming works.	E①

2. Corrective Measures for Preventing Recurrence

(4) Reshuffling education curriculum

Corrective measures	Correlation to root causes
- Add to the existing education curriculum in the company more contents regarding the insufficient areas, such as product safety, risk management, analysis of past manufacturing projects, and preliminary verification, and have **the dedicated departments, including Quality Assurance, Design, and Manufacturing, review the education curriculum aross departments.**	E②
- Enhance the human resources skills map, comprehend the level of work performance on each organization basis, utilize such information for organizational management, and **reshuffle the education curriculum to correspond to the targets for human resources development.**	E②

Diagram ②: Correlation between the actions/judgments that led to the manufacturing defects and their root causes, and the corrective measures for preventing recurrence



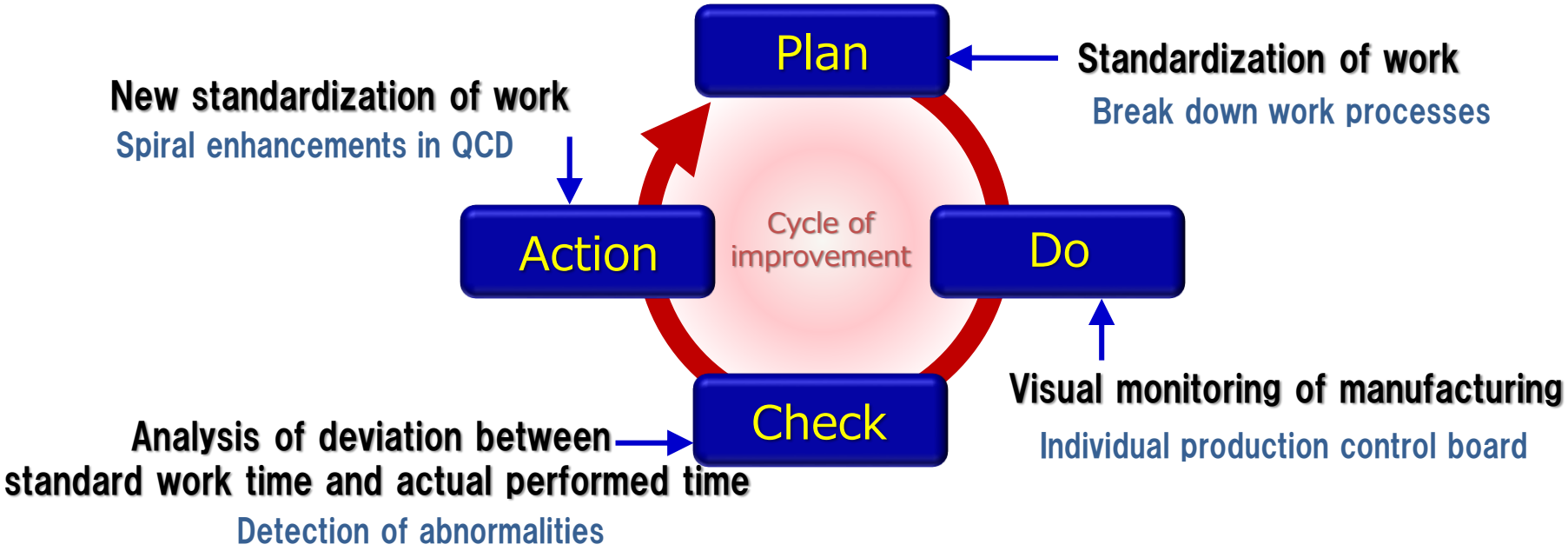
(Reference) Glossary

No.	Term	Explanation
*1	Rolling Stock Company	The company responsible for the rail car business, among the companies in the six fields in which Kawasaki Heavy Industries, Ltd. is developing its business (Ship & Offshore Structure, Rolling Stock, Aerospace Systems, Energy System & Plant Engineering, Motorcycle & Engine, and Precision Machinery & Robot).
*2	Deposit welding	A common procedure used to compensate for grinding off and repair dimensional adjustment.
*3	Variation Tree Analysis (VTA)	An analysis method that goes through the process that led up to the occurrence of a defect with the emphasis on human actions and judgments. It assumes there is tree-like branching in a time series, and is used to identify the "branch points" of the actions or judgments that caused the defect to occur.
*4	5 Whys Analysis	A method which aims to ultimately reach the fundamental cause (root cause) of a problem, by presenting a factor (a "why") which caused the problem, then presenting a factor (a "why") which caused that factor, and repeating this process five times.
*5	Welding bead	A bulge of welded metal created as a result of fusing a welding rod, etc. at the welding section and building it up.
*6	KPS (Kawasaki Production System)	See page 23
*7	Work guidelines	Materials that supplement the drawings. They are documents that communicate to the workers important notes and points of caution regarding performing the manufacturing work.
*8	Concurrent activities	Activities whereby multiple processes in product development are conducted simultaneously in parallel. Design, Development and the other departments in the upstream processes, and Purchasing, Manufacturing, Quality Assurance, After-Sales Service and the other departments in the downstream processes share information, and work together through cross-departmental cooperation to achieve, for example, designs that take into consideration using structures that will be easy to manufacture, and cost effective product development.

*6 KPS (Kawasaki Production System)

A set of production control techniques that are unique to Kawasaki Heavy Industries, Ltd. The aim of the KPS is to establish the standardized work practices in order to achieve the same quality constantly whoever does the work; and the shop rules to adhere to the standardized work practices.

The work processes at the manufacturing shop are broken down to standardized works, and a standard work time is set for each standardized work. The standardized work and the corresponding standard work time are shown on the individual production control boards for the manufacturing technicians, and the actual performance record for each standardized work is monitored in details.



PDCA cycle for improvements is always activated and enhancements in quality, cost and lead time of products spirally continue.