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Mizen Boushi in Mass Production: a framework for maintaining reliability in a dynamic environment

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Abstract

Mizen Boushi means "proactive problem prevention" and refers to methods developed by Toyota for maintaining product reliability through the design and development process by anticipating and mitigating potential quality risks caused by proposed design changes. *Mizen Boushi* theory can be applied to production operations as well, to develop the highly reliable supply chain required by the Toyota Production System. Process changes in a high volume environment occur more frequently than product design change proposals, and can be either planned or unpredictable; the theory suggests that changes should be avoided to maintain reliability. Using *Mizen Boushi* theory, the authors develop a framework for maintaining process and product reliability in a dynamic mass production environment, and then test the framework using case studies from a North American auto parts supplier. The proposed framework can help an auto parts supplier develop an organizational capability for reliability that can lead to competitive advantage in today's global marketplace.

Keywords
Reliability, *Mizen Boushi*, Change Point Control, Standardized Work

1. Introduction

When something is said to be reliable, it means that it can be depended upon with confidence to perform its intended function throughout its design life. Among global automobile manufacturers, Toyota and Lexus brand products consistently top independent industry studies of quality, dependability, and reliability (Mays, 2015, 2016; Treece, 2016). Product reliability is a key element in Toyota's strategy for success in the marketplace, and it has been achieved by employing a philosophy of problem prevention called *Mizen Boushi*. Toyota is also famous for the Toyota Production System (TPS), a highly efficient and tightly interwoven supply chain driven by a pull system from the market. TPS focuses on value added operations and elimination of waste, and is sometimes referred to in North America as Lean Production (Womack, Jones, & Roos, 1990). Because of the lack or small size of buffers such as inventory or excess capacity within the system, it is essential that all the components of the supply chain be highly reliable. Can the theory that Toyota used to develop product development practices that resulted in industry best levels of product reliability be applied to production operations in the supply chain as well? This paper will attempt to answer this question. After a review of the literature, a conceptual framework is presented to apply the theory to production operations. Using case studies from a parts supplier within the Toyota supply chain in North America, the framework was tested for applicability in predicting reliability failures or informing preventive actions. Discussion and summary follows.

2. Literature Review

Mizen Boushi is a Japanese term meaning "proactive problem prevention" which refers to methods developed by Toyota for assessing the susceptibility of new product designs to potential quality problems (McLeish & Haughy, 2009). With a goal of maintaining and improving product reliability throughout future design cycles, *Mizen Boushi* involves analysis of proposed new designs with particular focus on those elements that are different from the current, proven design.

Stable, robust products are the manifestation of a good design, and an essential tool used in the design process is the FMEA (Failure Modes and Effects Analysis). As the name implies, the FMEA prompts the design team to consider all kinds of potential problems that could arise from the proposed design conditions or features, then analyze and quantify the effects of these problems relative to the specification, and implement design countermeasures based on the results of the analysis. The FMEA is a living document through the various stages of the design validation process, and may be updated throughout the life cycle of the product as new problems are identified.

To maximize reliability, engineers should avoid changing the conditions of a good design once it has been achieved (Shimizu, Imagawa, & Noguchi, 2003). However, customer demands for lower cost, smaller size, and better performance, will drive innovation efforts that result in the need for design changes (Laurenti & Rosenfeld, 2009). Engineers know that risk lies within these changes, and success in preserving reliability depends on how effectively the design review process can recognize and deal with potential problems resulting from incidental changes to the design (Allan, 2009). The *Mizen Boushi* method was first taught in the United States at General Motors in 2003 by retired Toyota engineering executive and Kyushu University Professor Tatsuhiko Yoshimura, and was presented as the GD^3 process: Good Design, Good Discussion, and Good Dissection. Once a Good Design has been achieved through the use of FMEA, the Good Discussion analyzes any proposed design changes using a tool called Design Review Based on Failure Modes (DRBFM); a kind of a "lean" FMEA that focuses on the elements of the proposed design that differ from the proven one. Good Dissection utilizes a tool called Design Review Based on Test Results (DRBTR), and involves a tear down of parts after testing to uncover potential reliability concerns that may be addressed with countermeasures before the design is finally released for production (McLeish & Haughy, 2009).

3. Conceptual Framework

Although most of the literature related to *Mizen Boushi* is in the realm of product design, these concepts of proactive problem prevention for reliability can be applied to high volume production operations as well. Figure 1 below illustrates the proposed framework for this application.

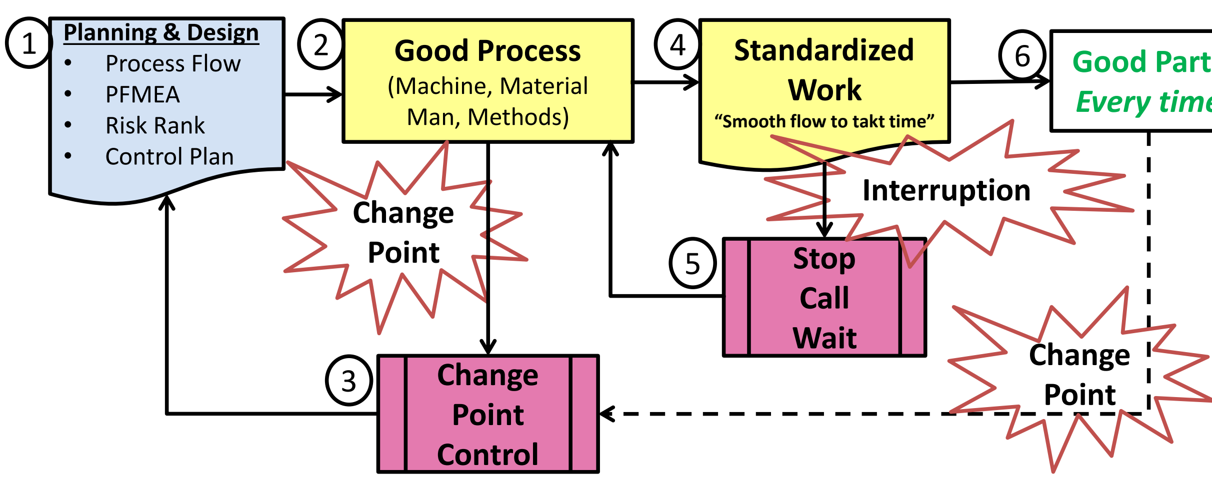

Figure 1. Framework for application of *Mizen Boushi* to Mass Production Operations

As shown in ①, the FMEA tool is also used in process design (sometimes called PFMEA), where the intended result is a Good Process; a system combining the elements of Machinery and Tooling, Materials, Manpower, and Methodologies to produce goods that meet design specifications at desired quantities and target costs [②]. Once we have achieved a Good Process, our risk of potential reliability problems in production lies in changing any of the elements of that process. However, the life cycle for process condition stability in high volume production is much shorter than that for a product design; process conditions in a mass production environment could change frequently, and sometimes unexpectedly. For an auto parts manufacturer using a Lean Production system, production is controlled by a market pull signal according to a level schedule, with the ultimate goal being one by one production according to customer demand. Within such a system process elements will have many planned change points during the course of daily operations. Other changes may be unplanned, as process adjustments may be required to countermeasure unfavorable conditions. In either case, the continued reliability of the process depends upon the identification and control of these Change Points [③]. Change Point Control procedures can take many forms, but all will involve a review of the original process design with respect to the potential reliability risks posed by the change under consideration, so that actions can be taken to ensure that the process remains "Good."

For a process to be reliable in mass production, it must produce Good Parts Every Time [⑥], meaning every time that the process is cycled; a key component in achieving this is Standardized Work for the operators [④], so that both work and motion flows smoothly within the *takt* time.[1] When this condition is achieved, the process is said to be in a state of flow, and we are confident that the process is performing reliably. If Standardized Work is subjected to Interruption for any reason (machine resets, downtime, components problems, etc.) then we are at risk of a problem happening. To deal with this risk immediately, we require a procedure called Stop-Call-Wait [⑤]; the operator can stop the process, and call a designated specialist to address the situation, review the process, and take necessary measures to return to a state of being able to perform Standardized Work in a Good Process.

In our framework we also consider Change Points originating from the external environment. For example, circumstances at a customer could result in a change to product acceptance criteria, thereby redefining what is meant by a Good Part. These situations need to be recognized and treated proactively as a change point that prompts a review of the process design to determine if the current elements are sufficient to ensure reliability of the output. Similarly, Change Points that occur in the supply base need to be recognized so that the current process design can be reviewed, and actions can be taken to mitigate any risk to the reliability of incoming material.

3.1 Standardized Work

Standardized Work is created by the production operators and the Team Leader, using the methodology of the Training Within Industry Job Instruction Module (TWI – JI). Job Instruction is the best method to teach someone quickly how to do a job correctly, safely, and conscientiously (Graupp & Wrona, 2006). An essential antecedent to this teaching is the breakdown of a job into its Important Steps, with Key Points for each Important Step, and corresponding Reasons for each Key Point. The Job Breakdown Sheet is used as the curriculum by the Trainer, who teaches each learner one on one through a series of iterations of showing and telling and confirming that the learner had mastered the job. When properly executed, all workers trained in this manner will perform each respective job the same way, because only the essential information is conveyed in the training using common terminology. Furthermore, this method forces the identification and proper arrangement of the necessary tools and materials required for the job, thereby accomplishing the first two steps of the 5S method for visual control.[2] Maintaining a good 5S condition enables everyone to recognize when Standardized Work is not being executed smoothly, indicating that variations or abnormalities are happening in the process, creating a potential reliability risk. When abnormalities are detected, the operator is expected to initiate the Stop-Call-Wait procedure.

3.2 Stop-Call-Wait

One of the challenges with strict adherence to the policy of Stop-Call-Wait is judging when the process needs to be stopped. If the purpose of Standardized Work is to maintain reliability by achieving a "smooth flow to *takt* time" (Liker, 2004), then in theory, any work cycle where this condition is not achieved would be cause to stop the process and resolve the issue immediately. In an assembly operation involving several operators producing hundreds of parts in a shift, this could result in a huge number of stops, as any variation in the operator's motion as a result of product condition or machine performance would trigger the *andon*.[3] In some cases, this might be considered impractical, as the variation might be considered to be a minor nuisance with an imperceptible variation in cycle time or flow; but in making that judgement we have allowed the "abnormal" to become "normal" and we are in danger of ignoring the

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[1] Takt time is the rate at which good products must be produced to meet customer demand. It is calculated by dividing the available working time for a defined period by the customer demand for that period.
[2] 5S is a tool for creating and maintaining visual control in the workplace. Each "S" stands for a Japanese term, for which the English versions are Sort, Straighten, Shine, Standardize, and Sustain.
[3] *Andon* refers to the visual system that indicates the status of a production operation. Each operator has access to a signaling device that can change the status indicator when a problem is detected, indicating that help is required.

potential reliability risk caused by such Interruptions. Ignoring a succession of nuisance items would ultimately result in a total absence of Standardized Work and our process reliability is now compromised. Proper action would be to invoke Stop-Call-Wait and allow the designated specialist to review the process and the Standardized Work, and if a process correction is not readily available, a modification to Standardized Work utilizing the TWI Job Instruction method may be required to mitigate any reliability risk.

3.3 Change Point Control

As stated earlier, a Good Process is a system combining Machinery and Tooling, Materials, Manpower, and Methodologies to produce goods that meet a) design specifications and acceptance criteria at b) desired quantities and c) target costs. A change in any of these three requirements will necessitate a process change; according to *Mizen Boushi* theory, this would require Good Discussion and Good Dissection of the proposed change for the preservation of process reliability prior to implementation. In mass production, some of these types of changes, although planned, can occur frequently on an ongoing basis with short lead time; therefore, control of these Change Points must be built into the process.

3.4 Predetermined Process Change Points

For reasons of economy and flexibility, many processes are designed to accommodate specific kinds of change points. For example, to maximize asset utilization, and to provide production flexibility, some processes are designed to produce more than one type of product. This necessitates that some elements of the process will need to be changed in order to go from producing Part A to Part B with no compromise in reliability. Another potential requirement for flexibility is the ability of a process to perform at various rates of output with no loss in efficiency or reliability. This may require changes in the manpower levels in the process as well as the methods employed. Change Point Control for these cases must be pre-designed and built in to the process to allow it to continue to run smoothly.

3.4.1 Product Changeover

A product changeover is a specific kind of planned change to design specifications that may occur several times per shift. In essence, we are changing the Good Process for one product into a Good Process for a different (but usually similar) product. According to the *Mizen Boushi* theory, control of this Change Point would necessitate that we highlight the specific process changes, and then identify the risk that these changes pose to the reliability of the process with respect to the specifications for either product. In the Good Discussion phase, control measures would be identified to mitigate or eliminate these risks, and these elements would be added to the process. Good Dissection would occur as we observe the actual output of the process, analyzing the products to determine the effectivity of the control measures for the product changeover. In ongoing mass production, it is impractical to idle the process for a lengthy Good Discussion several times per shift, so effective changeover controls are predetermined as part of the process design. In some cases these controls can be automated, but for changeover elements that are human dependent, Standardized Work is developed so that the production operators can successfully execute the changeover quickly, reliably, safely, and conscientiously. Not only must the Standardized Work include the Important Steps, Key Points, and Reasons for each task, there must be a trigger for the operator to know when to stop the process for the current product, begin the changeover process, complete the changeover process, and begin work on the new product. Also, since the reliability of any Standardized Work depends on a smooth flow to the *takt* time, then the cycle time requirement for the execution of the changeover process must be defined, so that abnormalities and interruptions can easily be recognized, and if these should occur, then the Stop-Call-Wait procedure should be initiated.

Aiding the facilitation of Standardized Work for product changeover is the use of *poka-yoke* devices so that the important steps of the changeover process can only be performed one way, or *jidoka* elements designed into the equipment and tooling to prevent further processing when required conditions are not met.[4]

[4] *Poka-yoke* means "mistake proofing" and refers to devices that make it impossible for an operator to do something incorrectly. *Jidoka* means "built in quality" and refers to the ability of a machine to detect process conditions and stop automatically when those conditions are incorrect.

3.4.2 Output Rate Change

Automated equipment is typically designed and controlled to perform at a fixed cycle time which is not easily adjusted.[5] However, some production systems consist of manual operations; in such cases, the rate of output of these systems can be changed by adding or subtracting manpower to the system.[6] Each addition or subtraction of manpower to the system is a Change Point that can introduce risk to the reliability of the system if not properly controlled. Each operator is performing Standardized Work, and the addition or subtraction of an operator will affect the scope of the Standardized Work of all the other operators. This is true regardless of whether or not the manual operation is in series or parallel with the system, as the flow of the work through the system will be altered. Output rate changes may be less frequent than the product changeover, but nonetheless must be predesigned and predetermined for the same reasons of practicality in mass production.

3.4.3 New Operator

A specific case of the planned output rate change by the addition of manpower occurs when the production operator being added to the system is new, or not fully trained on the job. In this case the reliability of the Good Process is at risk because it is unlikely that the new operator will be able to execute the Standardized Work smoothly and within the cycle time. According to the theory, this would trigger the Stop-Call-Wait process, which would become highly impractical very quickly. Therefore a specific control for this change point is to assign a Trainer to work alongside new operators when they are introduced to the process. The role of the Trainer is to use the Job Instruction methodology to train the new operators to execute the Standardized Work, to monitor their progress until they are able to achieve a smooth flow to takt time. The time required to get to this level of competency can be significant, as there may be several jobs and procedures within every process system. In addition to the manual operations in production, the new operator must be taught the specific Standardized Work for product changeover and output rate changes as well.

3.5 Kaizen and Toyota Kata

As previously mentioned, the innovation cycle demands continuous improvement, which drives engineering changes to products; this maxim applies to production processes as well. Continuous improvement proposals may be externally or internally driven. For example, a process change may be required as a result of a product specification change that was driven by customer demands for improved performance. Alternatively, changes in the social, political, or regulatory environment may necessitate a re-evaluation of the PFMEA, and process changes could result. Certainly an ongoing demand in the competitive marketplace is for cost reduction, and processes are constantly being evaluated for improvement opportunities; however, reliability must be maintained or improved even as cost is being reduced. As production team leaders utilize the Toyota Kata methods to drive *kaizen* activities, this will result in many proposed Change Points.[7] There exists an inherent conflict between the need for rapid continuous improvement and the desire to maintain reliability by minimizing changes: organizations must develop the capability to execute both without compromise to either. Expeditious methods must be developed for proper execution of the Good Discussion and Good Dissection steps within the context of the Toyota Improvement Kata. A sound principle from *Mizen Boushi* theory would be to minimize the number of simultaneous changes, even limiting changes points to one at a time so that causal relationships can clearly be observed. This principle is supported by the Toyota Kata methodology, which encourages rapid experimentation in a series of Plan-Do-Check-Act cycles, but always working on one problem at a time. Toyota Kata is patterned after the scientific method, which demands that a hypothesis exists before an experiment is undertaken; additionally, it is a requirement that the experimenter document the expected outcome before conducting the experiment. This step could be the opportunity for consideration of potential reliability risks as well as cost reductions or productivity improvements.

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[5] For some processing operations, it is undesirable to adjust cycle time significantly, as product characteristics may be altered (e.g. plastic molding or casting operations).

[6] There is an upper limit to the rate of output, governed by the maximum throughput rate of the “bottleneck” (slowest) mechanized operation.

[7] *Kaizen* is a Japanese term meaning “continuous improvement”. Toyota Kata refers to Toyota’s methods and routines for practicing and executing continuous improvement activities (Rother, 2010).

3.6 Unplanned Change Points

Unplanned changes in mass production generally are a reaction to unfavorable conditions that occurred unexpectedly. Typically examples of these would be a) variation in the conditions to specification of incoming material, or b) substandard performance or damage to equipment or tooling. Despite a company's best efforts for incoming material control and preventive maintenance of equipment and tooling, either of these unplanned situations may occur suddenly, and induce risk to the reliability of the designed process. A third example of an unplanned Change Point in production is casual absenteeism, but given that procedures and practices exist for planned manpower adjustments, this situation can be controlled with minimal risk to reliability. What is critical according to *Mizen Boushi* theory, is that we can clearly recognize the occurrence of a Change Point to a Good Process (Good Design); that we have a procedure to identify, evaluate and countermeasure the potential reliability risks (Good Discussion); and a method for evaluating the effectiveness of those countermeasures as input for future process designs (Good Dissection). As time is valuable in a mass production environment, it is incumbent on company leaders to develop managerial routines and procedures for dealing with unplanned change points in material conditions and machine performance quickly but thoroughly, so that the operation continues to run efficiently without compromise to reliability. By planning ahead to deal with the unexpected, we are engaging in proactive problem prevention, which is the philosophy of *Mizen Boushi*.

4. Methodology

Having developed a framework for achieving reliability in mass production using *Mizen Boushi* theory, we will test its applicability using actual case studies of process reliability failures from a North American auto parts supplier. The authors are management employees of the parts supplier and have firsthand knowledge of the case details. Case study is an appropriate research methodology as we are attempting to use the proposed framework to explain how and why a series of actual events occurred (Yin, 2009). After testing the framework to inform the cause of these failures, we can determine its applicability for use as a preventive tool.

4.1 TRQSS

TRQSS, located in Tecumseh, Ontario Canada, is a supplier of seat belt systems for passenger vehicles produced in North America. TRQSS is part of the TRAM Group, headquartered in Plymouth, Michigan, which is the North American subsidiary of Tokai Rika Ltd., based in Nagoya, Japan. TRQSS' production operations consist of Injection Molding of plastic parts and components, and Automated and Manual Assembly lines. TRQSS operates using the Toyota Production System.

4.2 Case #1 – Product Changeover

In this case a failure to properly execute a product changeover resulted in one box of parts not meeting the design intent being produced and shipped to a major customer.

On March 16, 2016 TRQSS received notification from a customer that their assembly department reported a problem with a seat belt retractor assembly. The part in question was difficult to install into the vehicle, and after installation the webbing could not be extracted. After removing the part from the vehicle, the customer found that the retractor frame subassembly was incorrect for that vehicle, although the identification label and the mounting hardware were correct (see Figure 2). A sort was initiated at the customer and nine additional parts exhibiting this condition were found (the box quantity for this part number is 10 pieces). TRQSS initiated containment activities which included a sort of all finished goods from the assembly line and the temporary addition of a second 100% inspection.

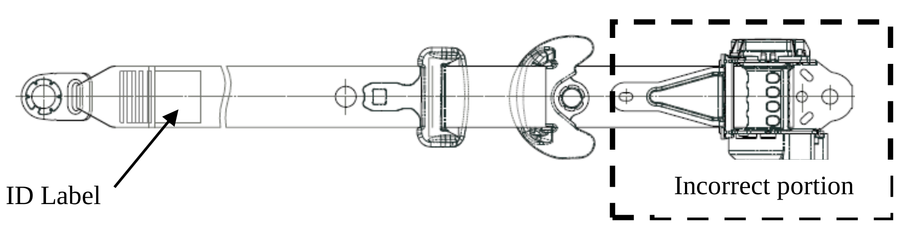

Figure 2. Seat Belt Retractor Assembly

While the containment activities were taking place an investigation began with a cross functional team of production, production engineering and quality associates. The line that produced the defective parts is called F25 (Figure 3). The F25 line builds 18 active and 38 past model service end items with an average of 25 product changeovers per shift.

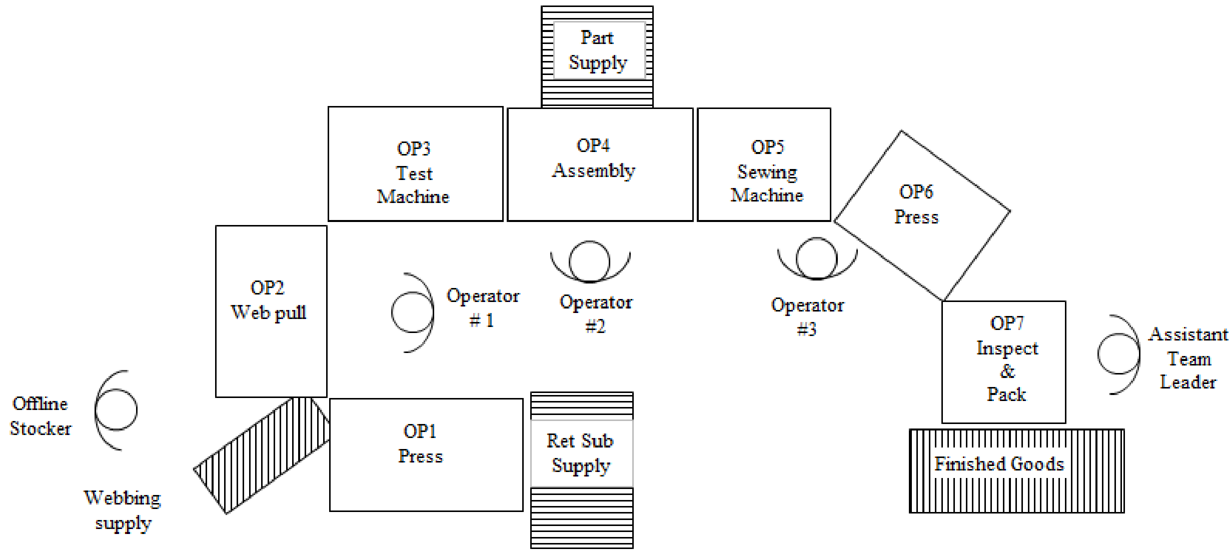

Figure 3. F25 Assembly Line

All finished goods from this line have a product identification label containing a serial number and bar code. The label bar code is scanned at the end of the assembly line (OP7) so it is possible to determine the exact time that the finished goods were produced. The station that joins the retractor sub assembly with the webbing sub assembly is called a web pull (OP2). The web pull has mistake-proofing to check for the correct retractor sub assembly and an overall extraction length check to make sure the correct webbing sub is being used. The Product ID label is added at OP5. The defective parts had the correct label but the wrong retractor and webbing subs. The line was checked and all machines were functioning correctly and the mistake-proofing was working. From the bar code scanning data, the team noticed that exactly one box of the parts in question was built right after the line returned from the scheduled afternoon break. It was determined from the records that a product changeover had commenced just prior to the break.

A product changeover is a standard process in all of the TRQSS assembly lines. One year prior to this incident a similar defect out flowed from another line. At that time it was determined that the defect occurred due to lack of standardized work for the changeover. Subsequent activities using the TWI job instruction method resulted in a three step process for doing any product changeover:

1. Clear the station
2. Setup the station
3. Verify the setup

All operators were trained on the new method and regular audits were instituted to monitor performance.

In this case, a product changeover was initiated just before the break. The trigger for a product changeover is a card issued by the Offline Stocker to Operator #1 inside the cell. When the card is issued, the Offline Stocker places the required components in the appropriate queue for the cell Operators; the retractor subassemblies are placed in advance of OP1 and the webbing is placed in advance of OP2. When the break commenced, Operator #1 failed to changeover OP1, OP2, and OP3and placed the changeover card after the test machine, just prior to OP4. The line went for break, and when they returned the Operators rotated jobs. The new Operator at OP1-OP3 did not see a changeover card and assumed the changeover had been completed. Operators #2 and #3 correctly performed the changeover after returning from break.

Operator #1 proceeded to build the first part and got a machine alarm at OP2 (webbing length incorrect). Rather than follow the protocol for Stop-Call-Wait and use the *andon* to summon the Assistant Team Leader, Operator #1 called the Offline Stocker and together they concluded that the wrong webbing must have been placed in the queue. The

Offline Stocker removed the webbing from the line and proceeded to get 10 new pieces of webbing (standard box quantity). The new webbing length is now correct for the retractor sub assembly being produced so the web pull machine will not alarm. Because the rest of the line did changeover, the wrong retractor / webbing subassembly was finished off with the correct hardware and label. The defective condition was not detected by the Assistant Team Leader at first off inspection.

4.2.1 Discussion of Case #1

Using our proposed framework for *Mizen Boushi* in mass production operations, we can identify where the operation became unreliable in this case. In the process Planning and Design phase, the PFMEA properly identified wrong retractor and wrong webbing length as possible failure modes. The process equipment contained mistake proofing elements for those failure modes and all equipment was working correctly; however, the mechanism for properly changing the equipment parameters to be able to distinguish one product from another was human dependent. Standardized Work was developed as a control measure for the human dependent elements of product changeovers, but in this case it was not followed, and the failure to follow Standardized Work was not detected. When the web pull machine alarmed after the changeover was supposed to have been completed, the Stop-Call-Wait procedure was not initiated.

The framework informs us that the failure to follow Standardized Work during the product changeover process and the failure to invoke the Stop-Call-Wait procedure when the web pull machine alarmed resulted in an unreliable process; defective parts were produced and shipped to the customer.

Does the framework highlight any opportunities for improvement in future? One area could be in the Process Design. Although the potential failure mode is identified in the Process Design, many of the changeover elements are human dependent. As a consequence, the Standardized Work for changeover contains many elements and successful execution is critical. Perhaps Production Engineers can improve the levels of *jidoka* and reduce the number of human dependent elements in the changeover. This would facilitate the execution of the remaining Standardized Work elements for the Operators. A second improvement opportunity is in understanding why the Stop-Call-Wait procedure was not followed when an alarm occurred on the first piece after a changeover. If invoked, the procedure would summon a specialist (Assistant Team Leader) to assess the situation and make the necessary adjustments. The solution to this issue is more behavioral than technical, but the framework highlights that everyone in the system has a responsibility and that responsibility must be clear to everyone. Any lack of understanding or execution compromises the reliability of the entire system.

4.3 Case #2 - Emergency Supplier Change

The focus of this case is an assembly consisting of 8 components. It is manufactured at a Tier 2 supplier and provided to TRQSS as a completed assembly in TRQSS' customer owned returnable containers in customer dictated quantities. Once it arrives at TRQSS, the customer specified label is applied to the box and it is prepared for shipment along with other end items for that customer. It is essentially a "pass through" part, not requiring any operations activity in the TRQSS facility.

In early April 2016 a notification was issued by Toyota Purchasing to their suppliers that a fire had occurred at a bolt supplier which crippled their in-house plating operations. In order to continue to supply, the bolt manufacturer had to seek alternate sources for plating. The bolt supplier had many customers throughout the auto parts supply chain, and Toyota was instructing all suppliers to assess their situation based on this development. The pass through assembly supplied by TRQSS contained a bolt produced by the supplier.

In a situation like this, time is a critical element. TRQSS supplies over 14,000 units a day of this assembly to various Toyota plants in North America, and with the fact that all our components are "Just in Time" supply, even small disruptions in the supply chain will result in downtime at the customer plants. However, it is also critical to maintain quality levels so when a Change Point like this is identified, we must go through the protocol established through our original *Mizen Boshi* activity and ensure the process still allows us to meet the design intent, the throughput requirements, and the target cost.

Fortunately, TRQSS had a significant amount of inventory on the raw bolt and Toyota had several suppliers in the area that performed plating on similar components; over the next few weeks a new plating process at a different supplier was stablished, and parts evaluation began without interruption to the flow of material. When the first parts arrived at TRQSS, they were sent to the lab for evaluation. At this point, one of the Lab Technicians noticed that the nut was difficult to thread onto the newly supplied bolt. Upon further investigation, it was found that the plating thickness on the new bolt was up to 3 times greater than the previous supplier's process and did not meet the

specification requirement for 7/16"-20 UNF-3A bolts. Over the course of the next few days, adjustments were made to the process to match the previous suppliers plating thickness and we were able to meet the inspection criteria of 3A Go/No-Go Gage checks, so the parts were deemed acceptable for use.
Unfortunately on May 16, 2016 TRQSS received a rejection from a customer plant highlighting the fact that the bolts were not meeting the fitness for use criteria required in their process. The components in question exhibited small dents in the thread area (See Figure 4), prohibiting the assembly operators from hand starting the bolt, which was part of their Standardized Work.

Figure 4. Small dents on bolt thread

TRQSS immediately confirmed the part condition against the drawing standard. According to the specification, small dents are allowed provided a 3A Go Gage can be applied to the first few threads without exceeding a pre-determined torque value (as dictated by thread size). In this case the parts in question met the criteria, but were still deemed unacceptable by the customer. Something further needed to be done.
Immediately, a rework process was implemented at the bolt supplier to chase the threads with a tapping die and/or re-roll the thread using a similar process to the original. This would ensure the small dents were removed prior to shipping to our Customer. Additionally, 100% inspection using an actual nut was implemented to confirm the bolt could be fastened by hand. Unfortunately the pipeline was already stocked with the previous level parts and eventually 2 more customer plants issued formal complaints about the components.

4.3.1 Discussion of Case #2

So what was missed? All the due care and problem prevention activity still resulted in a supply chain reliability issue, and allowed a problem to surface at the customer despite TRQSS' controls.
Using our framework, we can see that TRQSS was taking action to ensure that their good process continued to use good material after the bolt plating supplier change. The definition of good material used by TRQSS was the drawing specification for 7/16"-20 UNF-3A bolts. However the framework indicates that the goal of process reliability is Good Parts Every Time, and the definition of good parts is determined by the customer. At some point, a change had occurred in the customer process, and the step of hand starting the bolt was added.[8] The bolts from the original plating supplier presented no problem for the customer assembly plant, but the bolts from the new supplier did.
The framework informs us that Change Points that create a potential reliability risk can originate from the end user as well as from the supply base. In this case TRQSS was able to recognize the potential supply base risk but was unaware of the Change Point at the customer that posed risk.
In future, the framework suggests that the supplier needs to understand the customer operation where their supplied parts are concerned, and understand the actual fitness for use criteria; in this case, a criterion was not reflected in the quality specification for the component, which led to an erroneous assumption regarding the "goodness" of the supplied part. Awareness of this customer process Change Point and its potential effect on process reliability may have avoided the customer rejections, supply chain disruption, and extra costs.

[8] As a point of reference, an operator can generate about 0.5Nm torque when hand starting a nut whereas the specification limit for 3A bolt is 1.3 Nm for this application.

5. Summary

Quality problems happen when products and processes are unreliable. *Mizen Boushi* improves reliability by anticipating problems and eliminating them before they happen. To realize *Mizen Boushi* in mass production we have developed a framework that illustrates the respective roles of Process Design, Change Point Control, Standardized Work, and Stop-Call-Wait, and used case studies from an auto parts supplier to test its applicability. Future research should include further analysis of cases from other auto parts suppliers, including cases where application of the framework resulted in a successful outcome.
Product reliability is a competitive advantage for Toyota, and supply chain reliability is critical to the successful operation of TPS. This is easy to say, but difficult to do; success requires a relentless pursuit of excellence and in a dynamic, fast paced environment such as mass production, there can be temptation to stop activities when the results are good enough. In the competitive auto parts marketplace, and especially in safety devices, there is no room for good enough. Only excellence will ensure our survival.

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Biography

Mark Dolsen is President of TRQSS Inc., a supplier of automotive seat belt systems located in Tecumseh, Ontario Canada. He holds a Bachelor of Science in Electrical Engineering degree from Kettering University (formerly General Motors Institute), a Master of Science in Industrial Engineering from Wayne State University, and is currently a PhD candidate in the Industrial and Systems Engineering Department at Wayne State University. Mr. Dolsen has over 30 years of experience working in the automotive parts industry in engineering and management positions. He is a member of IIE, SAE, ASQ, and is a Licensed Professional Engineer in the Province of Ontario, Canada.

Eric Legary is Director of Engineering and Quality at TRQSS Inc. in Tecumseh, Ontario Canada. He holds a Bachelor of Applied Science in Mechanical Engineering from the University of Windsor. Mr. Legary has worked in the field of seat belt system design for 22 years, and participates on Automotive Safety Council's Seat Belt Technical Committee.

Murray Phillips is General Manager of Production at TRQSS Inc. in Tecumseh, Ontario Canada. Mr. Phillips has over 30 years of experience in Production Engineering and Production Management. He is a member of the Society of Manufacturing Engineers and is a Senior Member of ASQ.