Developing an Ideal Production Operator [1]

Koichi Kimura, Factory Management Institute
Gregory H. Watson, Business Excellence Solutions, Ltd.

Foreword

The Second World War (WW II) devastated Japan. Most of its national infrastructure was totally destroyed as a result and its American occupation force, under the Direction of General Douglas MacArthur, sought to rebuild the society. In its efforts, it dismantled many of the social structures and systems that were believed to have instigated the war-fighting spirit of Japan and established a constitutional government that embodied peaceful coexistence as a core principle in its newly established national culture. In order to establish a firm foundation that linked to traditional Japanese culture. MacArthur's reconstruction of Japan reinforced core aspects of Japanese culture that we recognize in today's management language as the 3-S daily management activities (Seiri-Seiton and Seisou). These principles were long-established in the Japanese Shinto and Buddhist traditions and became firmly embedded in all industries that emerged from the ashes of destruction after WW II. MacArthur's administration also enabled the new traditions of Japanese Management to be introduced based on lessons learned from American efforts and adapted to Japanese culture. Quality management is perhaps the best known of these adaptations which became greater than the capability of the originating concept. Worker training was a second aspect. This paper reflects upon the development of the unique industrial training program of Japanese industry and how it developed "ideal production workers" through a pragmatic, long-term education and training program.

During this post-WW II era, Toyota learned lessons about how to manage its production processes more efficiently and effectively. Some of these lessons involved the development of manufacturing skills among its production workers which were derived from the American Training Within Industry (TWI) course. TWI was developed by the War Department's War Manpower Commission to train replacement workers who were inexperienced in the manual production skills necessary to manufacture the weapon systems required to support the war effort. TWI consisted of four original 10-hour training sessions (Job Instruction (JI), Job Relations (JR), Job Methods (JM), and Program Development (PM)) along with three additional programs (Job Safety (JS), Problem Solving (PS), and Discussion Leading (DL)) to supplement these core set of programs. The training programs were offered to Japan in 1948 to stimulate the effort at national reconstruction in the post-war period. [2]

TWI served as the foundation of the Production Course (P-Course) that was managed from 1947 to 1955 by Shigeo Shingo and conducted under the auspices of the Japanese Management Association (JMA). [3] A core principle of the course was "learning while improving" and the program concentrated on training people quickly to be effective and efficient production workers by developing their ability to see muda (無駄) in their work and to collaborate for continual improvement (kaizen (改善)). Shingo delivered these courses on a monthly basis at Toyota from 1956 to 1958 training approximately 3,000 workers. Approximately one third of the course was theory with the rest based on practical applications. Toyota adapted JMA's P-Course into its core production worker training program. The current Toyota training program takes a worker from the level of ignorance to the level of supervised practice on the job, following many of the same principles as the early TWI and P-Course actions. Figure 1 illustrates the five levels of training for a production worker at Toyota where the education effort is on recognizing waste and building sensitivity to cost and quality control. Once a worker has completed the indoctrination to production, then they are assigned to a supervisor for on-the-job training (OJT).

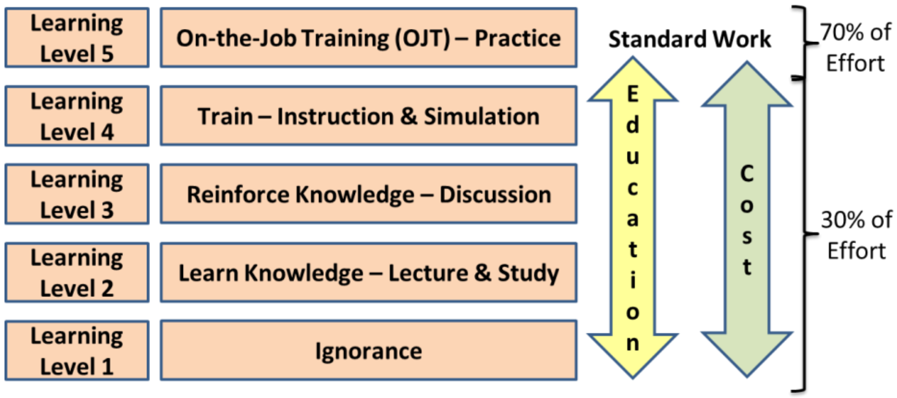

Figure 1: Levels of Learning in the Toyota Worker Development Program [4]

Introducing Production Education

This paper will describe an ideal operator in a production system and the important task of management of investing in its people by providing education and training as well as follow-on assessment in terms of skill evaluation and provision of incentives that are tied to these developments. Japan has a national system for qualification of "Machine Maintenance Technicians" does not have a parallel in the US or UK. It may be similar to national system of Germany that is called the Meister system.[5] But the Japanese system for qualification as a Machine Maintenance Technician is quite different. The premier companies in Japan encourage their production operators to acquire this qualification. The following paragraphs will describe the ideal development program and the content of this Japanese program.

National Qualification and Test for Machine Maintenance Technician

The Machine Maintenance Technician (MMT) national qualification certifies the ability of a worker to perform the maintenance of machines installed in factories and is a dominant qualification. There are three occupations for this qualification: Mechanical Maintenance Work, Electrical System Maintenance Work and Machine and Equipment Diagnostic Work. In each of these occupational areas there are four grades/levels of work: 3rd Grade (beginning technicians), 2nd Grade (intermediate technicians), 3rd Grade (advanced technicians), and Special Grade which corresponds to a supervisory function. The 3rd Grade is only applicable to the Mechanical and Electrical System Maintenance Work categories.

To acquire these qualifications, it is necessary to pass both a Practical test and an Examination or skill test. These subject examinations may be exempted by attending and completing a "certified vocational training short term course and machine maintenance course" that is conducted by JIPM (the Japanese Institute of Plant Maintenance). JIPM was first established in 1961 to provide "safe, secure, and reliable production and maintenance activities" and develop methods and training to "stabilize and improve quality" in industrial organizations (Https://jipmglobal.com/).

Figure 2 shows participants in a practical test of electrical skill. While there is some variation in annual participation in this program, there are typically about 30,000 examinees in the JIPM program each year.

Figure 2: JIPM Examination of Electrical Skills

Figure 3: JIPM Examination of Mechanical Skills

The photograph in Figure 3 illustrates the mechanical skill test. These people are representative of the company-sponsored participants in the program. The remainder of this paper provides the details of this qualification program and describes how it differs across the four grades. To reach the Special Grade will require over 10 years of practical experience based on this illustration

Prerequisite Qualification to the Examination*

• Special Grade: After passing the first grade, at least 5 years of practical experience

• Grade 1 [Advanced]: Over 7 years of practical experience

• Grade 2 [Intermediate]: at least 2 years of practical experience

• Grade 3 [Basic]: Work experience over 6 months

* Note: The years of experience depends on vocational training history and academic background.

Description of the Test Subject Matter and Focus Areas

Each of these four grades of qualification has its own body of knowledge and concentration for testing:

Special Grade

1. Process Control
2. Work Management
3. Quality Control
4. Cost Control
5. Safety and Health Management and Conservation of the Environment
6. Work Instructions
7. Machine and Equipment Management
8. Gemba Technology on Machine Maintenance

Advancement from Third [Basic] to First Grade [Advanced]

1. Machine General
2. Electric General
3. Machine Maintenance Method General
4. Material General
5. Safety and Health
6. Elective Subjects (examinees must choose one of the following subjects)
    i. Mechanical Maintenance Method
    ii. Electrical System Maintenance Method
    iii. Equipment Diagnostic Method (Grade 1, Grade 2 only)

Practical Exam

The practical examination for the Special Grade is a “paper” test, rather than a demonstration test that covers the following topics:

- Process Control
- Work Management
- Quality Control
- Cost Management
- Safety and Health Management
- Work Instructions
- Machine and Equipment Management.

Practical examinations are conducted at all Grades (e.g., basic, intermediate, and advanced) and the content of these pragmatic examinations are described for each category of the qualification as follows:

Mechanical System Maintenance Work

Grade 3 [Basic]:

- Type and name of the part for the judgment of tool, measuring instrument,
- Determine of oil & lubricant,

- Determine of bearing, bolt, key, pin, sealing device,
- Determine of pneumatic device, and picture of the indicated valve.

Grade 2 [Intermediate]:
- Determine the oil & lubricant,
- Determine the cause of the defect occurring in the main constituent elements of machine,
- Inspection method at the time of abnormality of the machine,
- Cause judgment and countermeasures,
- Characteristics of the sealing device, the usage method, etc.

Grade 1 [Advanced]:
- Determine the oil & lubricant,
- Determine the cause of the defect occurring in the main constituent elements of the machine,
- Inspection method at the time of abnormality of the machine,
- Cause judgment and countermeasure,
- Characteristics of the sealing device, usage method, etc.

Electrical Maintenance Work

Grade 3 [Basic]:
- Task 1: Based on the instructed specifications, use the relay and the timer on the test board to wire the input 2 points and the output 2 points, complete the circuit, then operate it.

Grade 2 [Intermediate]:
- Task 1 and 2: Assemble the circuit of the sequence time chart using the programmable logic controller (PLC) and input the program. Also, add the indicated specifications. In task 1, grade 2 is a wiring operation of 3 inputs and 3 outputs, and the time chart is simple. Task 2 (same as Grade 1).
- Task 3: Check relays and timer relays. Also check the contact sequence circuit and repair the defective part. Although it is only the time chart in the Grade 1, the Grade 2 is simple because the wiring diagram is presented before the test.
- Task 2: Change the instructed contact sequence circuit. (Task 1 and Task 2 total)
- Task 3: After inspecting the given relay and timer using a circuit meter (tester) and a test board and filling in the answer sheet, inspect and restore the contact sequence circuit.

Grade 1 [Advanced]:
- Task 1 and 2: Assemble the circuit of the sequence time chart using the programmable logic controller (PLC) and input the program. Also, add the indicated specifications. In task 1, wiring operations of 3 inputs and 4 outputs are performed and a program of the basic time chart is inputted. In task 2, the circuit of task 1 is used to make three specified specification changes.
- Task 3: Check relays and timer relays. Also check the contact sequence circuit and repair the defective part. Judge defects of relays and timers and respond. A good point relay and a timer at this time are used for the contact circuit, a time chart is presented, and three wiring correcting operations are performed (disconnection, no wire, miss-wiring).

Machine and Equipment Diagnostic Work

Machine maintenance work must be able to judge and determine the presence or absence of symptoms and anomalies in a part based on measured numerical data for specialized contents related to using the diagnosis technologies which have been developed in recent years.

- Topics of the Examination for Grades 1 [Advanced] and 2 [Intermediate] – questions relating to:
    - Formulation of machine & equipment diagnosis plan
    - Setting for data collection by vibration measurement
    - Data collection by insulation measurement test method
    - Data collection required for oil pollution analysis
    - Selection and application of inspection methods for data collection by non-destructive inspection
    - Analysis and determination of measured data of precision diagnostic vibration measurement results on rolling bearings, gears, axes / rotors
    - Analysis and determination of measured data of simplified diagnostic vibration measurement results on speed reducer, fan / blower, pump / compressor
    - Analysis and determination of the measurement data of the insulation measurement execution result relating to cables and electric motors
    - Analysis and determination of measured data of oil pollution analysis results on rolling bearings, plain bearings, gears, and screw compressors
    - Analysis and determination of assumed data on non-destructive inspection
    - Characterization of the type of damage and problems related to its occurrence factors and countermeasures
    - Determination of maintenance method based on diagnostic results of equipment

- Second Grade: While the scope or range of subjects covered in the 1st and 2nd Grade examinations is common, the questions asked in the Grade 1 examination are more detailed and difficult to answer than those in the Grade 2 skill and knowledge examinations (e.g., requiring more comprehensive knowledge in terms of depth and detail) and the number of questions is also larger.

This content has been condensed from Japan's national qualification and test for "Machine Maintenance Technicians."

An ideal operator is one who obtained the appropriate national qualification, can operate the machine, and is able to conduct autonomous maintenance of the equipment.

The purpose of introducing this Japanese national qualification is to emphasize the importance of each company for investing in its people and, also illustrate the basic necessary skills and knowledge that are required for effective and efficient machine maintenance.

However, this paper does not describe either the specific knowledge or necessary skill that are needed to obtain this national qualification. In most countries, it may be too high a hurdle to obtain a credential like this Japanese national qualification. But no matter what the case, it is necessary to educate all of the Gemba workers and those who are involved in TPM through a program of education and training. This paper only describes the minimum necessary knowledge and activities to create such an education and development program. Further work will be required to make it effective and enduring.

Projected Perspective:

This discussion begs the issue: how does this structure compare to Western approaches for training and developing production workers? In the traditional Western approach the production job is analyzed using a Work Breakdown Structure (WBS) to identify the specific tasks that enable activities to be done in production processes. Next a Job Task Analysis (JTA) is performed to determine what are the specific areas of development required to do the specific tasks: what is the required worker aptitude, essential knowledge, skill required, and competence level to perform the required task? The next activity is to conduct a needs analysis by evaluating the ability of an individual worker to perform this job. It consists of an objective test in the subject matter and skill performance area and determination of any gaps in competence where a worker needs development and concludes with the specification of a training plan for developing worker capacity to perform. The final component is the training record which documents the completion of training and the demonstration of achievement of the skill and closure of the performance gap. While this traditional approach was developed in the West, Micro to Small-to-Medium-Sized Enterprises (M to SME) do not often follow such a structure. In fact, many multinationals have also de-formalized their training and development programs.

In a recent global study of executive attitudes about capability-building in organizations performed by the McKinsey & Company consulting firm, the vast majority of executives increased their perception of the importance of capability building in their organization as a result of their experience in the COVID-19 response. Figure 4a illustrates the attitudinal shift that occurred in terms of their opinions about a need for capability development to encourage long-term growth:

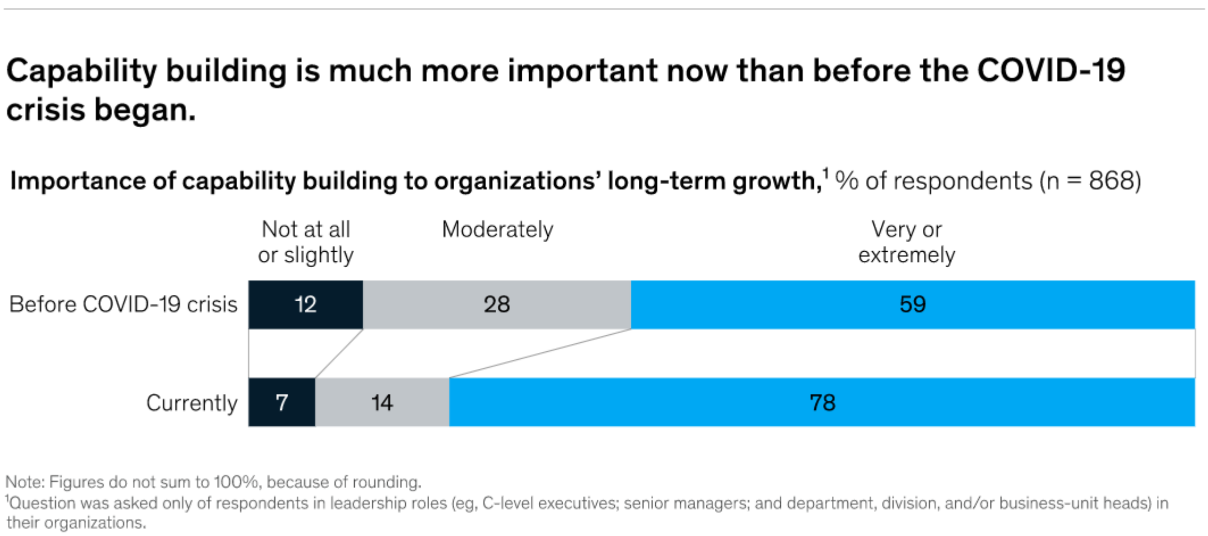

Figure 4a: McKinsey Global Study of Company Leaders [6]

Additinally, most of their companies plaec a high or very high value on learning as a component of their organizational culture as indicated in Figure 4b.

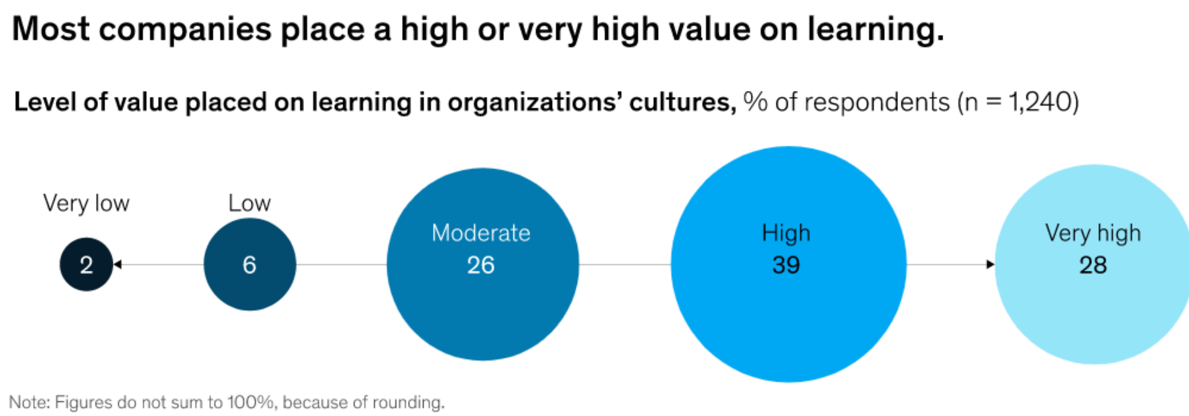

Figure 4b: McKinsey Global Study of Company Leaders [6]

However, despite these indicators of perceived importance, the McKinsey study pointed out that a vast majority of these same executives had not developed a clear plan for developing these long-term, high-priority personnel capabilities (see Figure 4c).

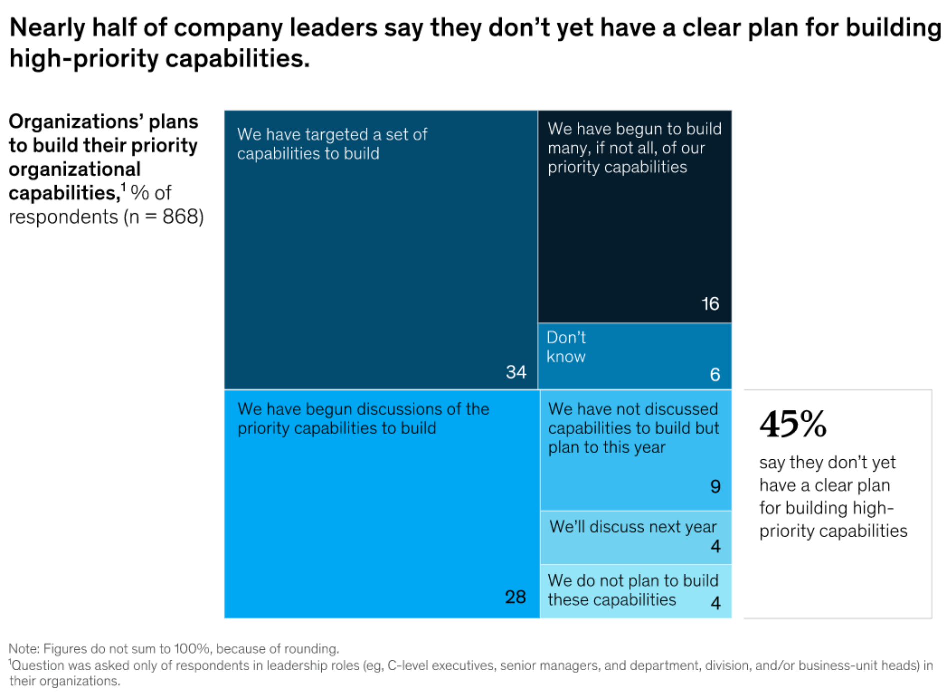

Figure 4c: McKinsey Global Study of Company Leaders [6]

This is an important observation as it indicates a more casual approach to worker development that is found in the traditional Japanese approach to employee training and education for production work.

Reflective Questions:

1. Compare this program of development to the Middle Ages Guild system in Europe with its levels of worker development from Apprentice to Journeyman to Craftsman levels of mastery. Why did this European system disappear in modern production activities in many nations? Does your own nation still possess such a sequential development system? If so, how does your national system compare to that of Japan?

2. Review your internal program for hiring and developing production workers. Have you developed a skill matrix for each position that requires unique operator competence?

3. Does your operator development program include a structured process that is applied to all workers beginning with indoctrination and allowing them to progress to the level of master over a period of time by participating using a career development program similar to that of this Japanese national qualification system?

4. How do workers demonstrate their progressive development of competence in all of these required skill areas? How is their work audited to assure that they practice their skills properly? What OJT is used to "polish" their skills over time? How do the experienced workers act as coaches or mentors to develop entry-level employees as they pursue the journey toward becoming expert craftsmen?

5. How does your organizational attitude about training and development compare to the companies in the McKinsey Company survey? Have you followed the route of formal needs assessment and job skill analysis to understand what must be developed as future competence areas for the key people in your most strategic work areas?

6. How do you update your skill requirements for the new production technologies that are required to support the digitalization of operational work?

References:

1. Koichi Kimura (2018), *TPM-4 Total Preventive Maintenance: Jisu Kanri* (Mie, JP: Factory Management Institute), pp. 11-16. FMI – The Factory Management Institute. Published under license of Creative Commons — Attribution-NonCommercial-NoDerivatives 4.0 International — CC BY-NC-ND 4.0. Published with the permission of Koichi Kimura.
2. Records of the War Manpower Commission [WMC] | National Archives. Cf: Donald A. Dinero (2005), *Training Within Industry: The Foundation of Lean* (Portland, OR: Productivity Press); Donald A. Dinero (2016), *The TWI Facilitator's Guide* (Boca Raton, FL: CRC Press); (2017) *Training Within Industry: Job Instruction* (Portland, OR: Productivity Press); (2017) *Training Within Industry: Job Relations* (Portland, OR: Productivity Press); *Training Within Industry: Job Methods* (Portland, OR: Productivity Press); Bartosz Misiurek (2016), *Standardized Work with TWI: Eliminating Human Errors in Production and Service Processes* (Portland, OR: Productivity Press); and William M. Tsutsui (1998), *Manufacturing Ideology: Scientific Management in Twentieth-Century Japan* (Princeton, NJ: Princeton University Press).
3. *JMA グループの原点 The DNA of JMA Group - JMA Group no genten (The origins of JMA Group)*, Edited by JMA Group renkei sokushin iinkai, Tokyo 2010 - pp. 34–35. [in Japanese] as reported in Wikipedia: P-Course - Wikipedia.

4. Toshio Horikiri (2018), *Toyota Management System Presentation* (Nagoya, JP: Toyota Engineering Corporation).
5. Maister Craftsman: In Germany and Austria, the word Meister also assigns a title and public degree in the field of vocational education. The German Meister title qualifies the holder to study at a University of Applied Sciences (UAS), whether the Meister holds the regular entry qualification or not. In 2012 the commissions of the states and the federal government, also the associated partners, concluded that the "Meisterbrief" is equivalent a bachelor's degree, ISCED 6). The Master craftsman is the highest professional qualification in crafts and is a state-approved grade. The education includes theoretical and practical training in the craft and, also, business, and legal training and includes the qualification to be allowed to train apprentices as well. The status of Master craftsman is regulated in the Crafts and Trades Regulation Code. To become a Master Craftsman usually requires vocational training in the specific crafts in which the examination should be taken (Gesellenprüfung). In addition to attaining the journeyman (Geselle) degree, until 2004 the Crafts and Trades Regulation Code did furthermore require practical experience of 3 years as a journeyman. In the German field of Meister education specialized training courses for the Meisterprüfung ("Meister examination") can be followed. The duration of the courses can take 1 to 2 years. The examination includes theoretical, practical, and oral parts and takes 5 to 7 days (depending on the craft). In some crafts creating a masterpiece is part of the examination. This note has been edited from the entry in: https://en.wikipedia.org/wiki/Meister.
6. Marla M. Capozzi, Stacey Dietsch, Daniel Pacthod, and Michael Park (2020), *Report: Around the world there is a big disconnect around employee skill building*, (New York: McKinsey & Company), [released 8 December 2020, downloaded on 10 December 2020 from: https://www.mckinsey.com/].

About the Authors:

Koichi Kimura is an international consultant specializing in the subjects of the TPS (Toyota Production System), TQM (Total Quality Management), TPM (Total Productive and Total Preventive Maintenance), Kaizen, and Factory Management Systems. He is an expert in the introduction and improvement of these systems through personal growth and assistance to the management for the change organization. Mr. Kimura had worked in the production operations for over 45 years during which he developed local JIT production systems as a supplier to the Japanese automotive industry at SUMITOMO Corporation. He advanced from an entry-level engineer to General Manager and during this entire period he was consulted both internally and externally on factory management systems design, development, and improvement. Mr. Kimura has been an international consultant for 22 years and worked on over 11 countries. He continues to apply these methods and is currently researching how to apply them in the evolving digital technology environment of Industry 4.0 and the Internet of Things.

Dr. Gregory H. Watson, EUR. Ing. Has been a professional in the fields of industrial engineering and quality management for over 40 years and is Past-Chair and Honorary Member of both the International Academy for Quality and the American Society for Quality. His commercial quality career was developed at Hewlett-Packard, Compaq Computer, and Xerox while his principal consultancies have been at Nokia Mobile Phones, Toshiba, ExxonMobil, and the major industries of Finland where he worked since 1994. He has the distinction of being the only Western person to have received the W. Edwards Deming Medal from the Union of Japanese Scientists and Engineers (JUSE) in 2009 – the Distinguished Service Award for Promotion and Dissemination (Overseas).