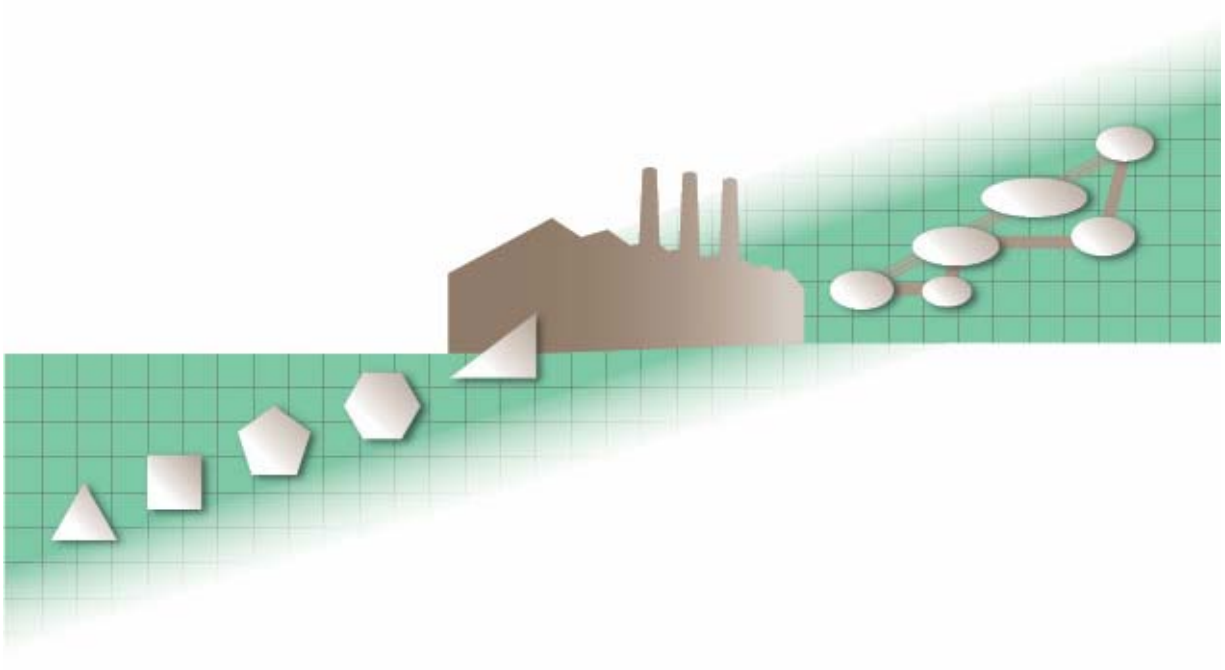
Industrial Management and Engineering – The Next 50 Years



Proceedings of a Panel Discussion

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To commemorate 50 years of service

RICHARD MUTHER & ASSOCIATES

Consultants in Industrial Management and Engineering

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Introduction

To mark the occasion of our 50th year, Richard Muther & Associates hosted a panel discussion on the next 50 years of industrial management and engineering. These proceedings contain a transcription of the panel's remarks, audience discussion, and written remarks of the panelists prepared in advance.

The purpose of the panel was to provide guidance for young people entering the industrial engineering profession. Our primary goal was to identify trends, directions and likely changes in the field and profession that may be helpful in career planning. A secondary goal was to help current practitioners and educators adapt to future demands.

Chaired by Richard Muther, our panel consisted of distinguished and authoritative industrial engineers, managers, and educators with international experience in manufacturing, distribution, office and service work. Their individual achievements are listed on the next two pages. Together, they have authored more than 20 books in our field, dozens of handbook chapters and hundreds of technical papers. They helped to found and have held top offices in leading professional groups and associations. Our panelists have trained thousands of engineers and managers around the world. Several have held key management positions in industry and their collective work experience is more than 200 man-years.

Attendance was by invitation. The panel's audience consisted of current and former associates of Richard Muther & Associates, clients of the firm, professors and industrial engineering students from leading Midwestern universities. Several generations of industrial engineers and managers were present and the discussion was wide ranging.

To students, we hope that you will find these proceedings insightful, stimulating and useful as you plan your education and your future career in industry.

To educators, we hope that the reflections, predictions and discussions contained here will help you in developing our next generation of professionals.

To practicing mangers and engineers, we hope that you also will find value and guidance as you plan for continued personal and professional development.

H. Lee Hales
President
Richard Muther & Associates

About Our Panel

Richard Muther, PE, CMC, PCMH

- Founder, Richard Muther & Associates.
- Degreed industrial engineer; honorary doctorate from Lund University.
- More than 50 years of consulting and training assignments on five continents.
- Developed and taught the first-ever course on mass production methods (M.I.T. 1942). Authored first text in America on Production Line Techniques (1944).
- Author of 14 books translated into more than 20 foreign-language editions; author of more than 100 technical papers and handbook chapters.
- Co-founder and Past President of the Association of Professional Material Handling Consultants.
- Founder and Chairman, Institute of High Performance Planners (IHPP).
- Developer of the High Performance Planning model and Planning by Design -- systematic methods for better planning in all walks of life.
- Creator of Systematic Layout Planning
- Recipient of the Gilbreth Medal for his outstanding contributions to industrial engineering.
- Recipient of the Reed-Apple Award, the Don Francis Award, and several other awards for contributions to the field of materials handling.

Dr. Gerald Nadler (Due to illness, Dr. Nadler was unable to attend but submitted thorough written answers to each question. These are included).

- President, The Center for Breakthrough Thinking® Inc., an international consulting firm dedicated to improving the effectiveness of engineers, planners and managers.
- Former president of the Institute of Industrial Engineers.
- IBM Chair Emeritus in Engineering Management and Professor Emeritus of Industrial and Systems Engineering at the University of Southern California.
- A life-long educator; formerly on the faculties of Purdue, Washington University, and the University of Wisconsin.
- More than 750 invited lectures at universities, companies and conferences around the world.
- Author of more than 200 published articles and 13 books, several of which have been translated into eight languages.

Dr. Richard E. Ward, Ph.D., PE

- Executive Vice President-Professional Development, Material Handling Industry of America -- engaged at the center of the worldwide material handling industry.
- B.S., M.S. and PhD degrees in industrial engineer;
- Former professor and life-long educator; internationally-known as a leader of short courses and seminars on inventory and supply chain management, warehousing, and material handling.
- Past director of the Institute of Industrial Engineers' (IIE) Transportation and Distribution Division.
- Active member of APICS and NSPE.
- Member of the College-Industry Council on Material Handling Education.

About Our Panel

Chas Scheiderer

- Senior Vice President – Logistics, Best Buy.
- Degreed industrial engineer with MBA.
- Formerly with Payless Shoes and Quaker Oats.
- Distinguished career in warehousing, materials handling, and transportation.
- Extensive experience with performance measurement, leadership, teamwork, and personnel development.
- Former RMA associate – our most distinguished in industry.

Dr. Hakan Bütüner

- Consultant and educator.
- President IMECO Industrial Management & Engineering, Istanbul, Turkey.
- B.S. in Industrial Engineering; MBA; PhD in Engineering Management
- Associate Professor of Industrial Engineering, Okan University.
- Associate Professor of Industrial Engineering, Bahçeşehir University
- Former manager in industry.
- Author of technical papers on business strategy and information systems.
- International affiliate of Richard Muther & Associates.

Ben B. Graham

- President and CEO, The Ben Graham Corporation (a training, consulting, and software organization.)
- B.A. in Economics; MBA
- Recognized authority on process improvement with emphasis on the white collar workplace in government agencies, non-profits and private enterprise, including: R&D, legal, finance, information technology, and customer service departments.
- Personally trained more than thousands of people in the United States and abroad in the techniques of work simplification.
- Author of articles, papers, and text on process charting and process improvement.

H. Lee Hales (Moderator)

- President, Richard Muther & Associates.
- Founder, High Performance Concepts, Inc.
- Internationally-known industrial engineer and information systems planner.
- Author of several popular books and educational videos on industrial planning, including Japanese and Chinese editions.
- Contributor to leading handbooks on industrial and manufacturing engineering.
- Guest lecturer at Georgia Tech Logistics Institute; former guest lecturer (and graduate) Massachusetts Institute of Technology.
- Past member of the College-Industry Council on Material Handling Education.
- Has personally trained several thousand managers and engineers in 20 countries.

The Panel Questions and Ground Rules

Panel Topic: Industrial Management and Engineering – The Next 50 years

1. Within North America, what are the two or three most significant developments or changes in the past 50 years of industrial management and engineering?

2. What about in the rest of the world?

3. Has the rate of technical innovation permanently slowed in material handling, warehousing, and factory automation?

4. Is industrial management similarly mature?

5. Are Lean Manufacturing (the Toyota Production System) and Six Sigma the final expressions of industrial engineering? Is there anything more to know or do?

6. What are the fundamental technical skills needed by industrial managers and engineers?

7. Will industrial engineering exist as an academic discipline and degree in 50 years?

8. Will industrial engineering exist as a sizeable and well-defined profession in 50 years?

9. What will be the most significant developments in the next 50 years of industrial management and engineering?

10. What advice would you give to a young person entering our profession today?

Panel Ground Rules:

- The moderator will pose each question, coupling those that are closely related.
- The moderator will chose a panelist to lead off each round of discussion.
- Up to 10 minutes of panel discussion per question, including one or two questions from the audience.
- There will be no break during the two-hour panel session.

Audience Ground Rules:

- A microphone will be available for audience members to ask questions.
- When asking your question, please begin by identifying yourself and your affiliation into the microphone as we are recording for transcription and eventual publication of proceedings.

Panel Discussion

Lee Hales, Moderator:

I'm directing our first general question to Richard Muther. Within North America, what do you see as the two or three most significant developments or changes in the past 50 years since our firm was founded in Kansas City in 1956?

Richard Muther:

For me the biggest movement or change that has come into our whole industrial complex is the significance of systems analysis and the computer. And that tool, that device has changed the whole profession in terms of getting away from the shop floor and getting into the aspects of software. I think that's a major fundamental change. The other change that I see is perhaps less encouraging and that is the uncertainty of industrial engineering as a term. We have danced around that by changing the names of departments at various universities to management engineering, to manufacturing engineering, to systems engineering, to industrial engineering, and on and on. So it's a little bewildering to those who are not close to the profession as to just what it is that industrial engineers do. Because of this, I see the redefinition of the term as a very important aspect of where we're going.

Dick Ward:

I'll add to that, that I can't disagree at all with Dick's comments. There were three things that struck me when I first heard the question. First is the broadening of skills sets required of graduating industrial engineers from what they used to be. Skill sets today are so much broader than they were 50 years ago. We began with work measurement and work simplification and have now added quality control, human factors, manufacturing systems, ergonomic statistics, operations research and more. All of those tools and skill sets have really broadened what an industrial engineer is capable of doing. I think that's a major change.

I relate this expansion of skill sets to the broadening or the deepening of the practice domains for industrial engineering. It's no longer just industrial engineering for manufacturing – it's banking, finance, warehousing and distribution, healthcare, and transportation services. I think that is another huge change that has occurred over the past 50 years.

And then one troubling change that was perhaps bound to happen has been the disbanding of large, centralized corporate industrial engineering departments. These, by and large, do not exist anymore. Or if they do, they're very few and far between.

Lee Hales, Moderator:

Interesting observation. I hadn't thought about the demise of the central department. I don't know how many of you in the audience share that observation, but that's definitely a big change in the years that I've been associated with the firm. We don't typically work with those departments anymore because they are not there.

Dick Ward:

Another thing that has disappeared from industrial engineering is the manufacturing focus. After I received my undergraduate degree from the first IE program in the nation at Penn State – and I won't date myself by giving the year – I spent time in a foundry. I spent time on machine tools. They don't do that much anymore in many of the departments in this country.

Chas Scheiderer:

Well, I think you find industrial engineers in all aspects of business now. So I like the term and I always think of the industrial engineer as someone with a full grounding in the management sciences and that understands the systems in place now. I agree that we've probably forgotten about a lot of the manufacturing processes. Now when you think of an industrial engineer, you think of someone that understands what queuing theory is, how the computer works, and how to apply systems analysis to a project. An industrial engineer is someone that you know is going to carry a project through. If you look at industry, the people leading much of the Lean and Lean-Sigma work are the industrial engineers.

Ben Graham:

From what I'm seeing on the information processing side, the focus on process today is coming out of IT departments and systems people as opposed to industrial engineers. In many cases, the IT folks are often reinventing tools and process analysis that has already existed in the realm of IE, but for them it's a new discovery. To me, this is a bit scary. With all the IT and systems people getting involved in process, we really should be digging into the good experience and resources that already exist.

Lee Hales, Moderator:

The second question asks about the most significant development in IE in the rest of the world. Chas, I'd like to aim this question at you since you had the most succinct written response. What about the rest of the world?

Chas Scheiderer:

Well, my response is actually a question in itself – is there really a difference? The biggest thing that has happened in industry over the past 50 years has been the computer, and its primary impact has been in the rest of the world. If you read Thomas Freidman's book, "The World is Flat," you realize that and it truly is. Think about the controversy over computer programmers in India doing work for U.S. companies. Well, those same Indian programmers are now being displaced by some programmers from Eastern Europe. The biggest development is having the computer and the communications and Internet capabilities that allow that whole world to be instantaneous. You can go on and on about the supply chain being totally visible now. These advances make it possible to immediately understand what a glass shortage at a manufacturing facility in Indo-China

will do to the supply chain downstream. The computer and the Internet make it all possible, so that's why I ask, "is there a difference regarding the significant developments in the U.S. versus the rest of the world?"

Lee Hales, Moderator:

I thought that was a great answer. And it made me reconsider posing the question the way I did in a connected world. Hakan, let me pose the question to you. You've studied in North America and have an industrial engineering degree from the University of Missouri, Rolla. You work in Turkey and you've worked in Europe and seen hands-on how industrial engineering is practiced abroad. What do you think about the first two questions?

Hakan Bütüner:

Well, Turkey graduated its first industrial engineers in 1971. Since that time, we have been accomplishing big things. I received my industrial engineering degree in 1983 in Austria and I was supposed to be in an industrial engineering role at my first job. But at that time nobody understood what an IE could do, so I actually ended up in a systems analyst role. After I had produced some results, I suggested that they organize an industrial engineering department, and they implemented the idea. Since that time, especially after Turkey and similar countries opened their economies to the broad global marketplace, they realized they would have to increase operational efficiency to compete. In turn, they recognized the value of industrial engineers. As I define it, industrial engineering helps increase the productivity of an operation. Whether it is in manufacturing or in another field, doesn't matter. Simply put, IE should increase productivity, and therefore increase profitability, of the firm. So if you define an organization from the three different categories of strategy, organization and operations, industrial engineers contribute to operational improvement.

Lee Hales, Moderator:

I think our first industrial engineering program in the United States probably graduated its first student around 1910. So we may have had a 60-year head start compared with Turkey. But what would you say today, Hakan? Would you argue that the skills and the applications are comparable in Turkey?

Hakan Bütüner:

If you only look at the issue from a single perspective you might say that. But if you look further into the details, you will see that a difference between the two remains. From a physical standpoint, you might say that everything looks the same. But when you go into details like structure of systems, skills, etc., you will see there is a huge difference.

Lee Hales, Moderator:

Let's go to question three now. Has the rate of technical innovation permanently slowed in material handling, warehousing and factory automation? I framed that question as a former computer integrated manufacturing (CIM) consultant who wondered what happened to the CIM acronym and all of the energy that was going into robotics and flexible machining and manufacturing systems, and AGVs. There was a lot of innovation in this area in the 1980s and even into the early 1990s that in my perception has leveled off. I'm going to ask Dick Ward to answer first because his written response to this question was so emphatic.

Dick Ward:

I believe across the board, that the rate of innovation in material handling absolutely has not slowed. In fact, I wouldn't even call it mature. So much change has occurred in this area and is still going on, much of it driven by controls and the information revolution, but also by a lot of clever engineering. And I'm reflecting more on the material handling world which I am closest to. But so much change is there, you just have to look under the hood to see it. Most observers think a forklift has three or four wheels and a fork that goes up and down, "so what else is new?" There are a lot of new innovations in drive systems, maintenance and ergonomics. These improvements are happening on a daily basis across many different technologies in our industry to enhance reliability, speed and functionality.

Richard Muther:

I would support what Dick Ward has just said with a quotation, "nothing happens without movement." Material handling and the problem of transportation and movement are still with us, even if it's only movement in the mind. If you take that quotation as being true, there are still tremendous challenges in material handling that will drive innovation.

Dick Ward:

I spoke about innovation in material handling, but certainly a lot of change is occurring in the distribution realm in how we organize distribution centers. They're becoming more centralized and larger. Every year, the industry is trying to improve the way we do order picking and fulfillment. My comment about innovation in material handling applies to warehousing, distribution and also manufacturing.

Chas Scheiderer:

To add to Dick Ward's point, I think RFID is a new technology whose potential is just being discovered right now. We are just scratching the surface of what RFID can do. Wal-Mart started using RFID in the retail business and forced their suppliers to do the same. But those suppliers are just now starting to understand the benefits of RFID to their own processes. RFID benefits them on the shop floor and in the handling of goods. I think there is also a big evolution occurring in the warehouse management system. So

many of today's warehouse management systems don't have all the capabilities that large, centralized warehouses really need. If you look at them, every one of them has a drawback and there is tremendous opportunity for improvement.

Lee Hales, Moderator:

Does anyone in the audience want to add on or ask a follow-up question on this rate of change or innovation?

Les Hannon, Audience Member:

I'm Les Hannon and I joined RMA in 1968 so I've been involved in materials handling for a long time. I think if we look at the rate of change, it's constantly increasing. And it's occurring in warehousing and materials handling, as well as the factory floor. We don't see as much innovation on the factory floor now because so much of it has gone overseas. Now we're more involved in the handling and distribution of materials being brought into the U.S.

Now that I'm retired, I can sit back and observe what is happening. The question today seems to center on how we can minimize the amount of space needed for storage. We've already enhanced the manufacturing process so that rather than make things in large vats we can make them as they are needed. As a result, we reduced the amount of storage needed by perhaps 80 to 90 percent. Now we're bringing things in by the container lot. And they have to be distributed and tracked. As I see it, the technology and improvements are just going to grow and change faster than they have in the past. The rate of change itself is more rapid and we're going to see that more and more.

Harvey Donaldson:

I'm Harvey Donaldson from Georgia Tech and I would like to respond to Dick Ward's comments. I agree with Dick that there is a lot of innovation in material handling and in factory automation. But I think what has fundamentally changed over the past 25 years has been the cost of labor. The availability of many immigrants coming into the United States, particularly in low wage jobs we thought would be automated by now, has affected the rate of innovation in materials handling. It's slower also because of outsourcing labor out of the country. So while there is innovation, it may appear that innovation in materials handling is stymied because we have a much more abundant and cheaper labor pool.

I think this may be reversing now. This year, a robotics company from Germany funded a new laboratory at Georgia Tech. They see new opportunities for robotics applications not only in automotive assembly, but across warehousing and distribution center operations. We recently met with the company leadership from Germany and I told them, rather than spending their money on R&D now, it might be a better investment to lobby Washington for tighter immigration control. That may be the answer to advances in materials handling technology.

Lee Hales, Moderator:

Let's move on to question four, "is industrial management similarly mature?" Both Gerald Nadler and Dick Muther took a little bit of issue with the way I used the term 'industrial management.' I was trying to encompass the operations management practices that we've all come to know as the Toyota Production System, which combines pull systems, vendor-managed inventory, and other practices that are not really industrial engineering. To me this term encompasses a bit of materials management, some manufacturing management and some logistics management. And the questions are, do we know everything we need to know? Is there more to be learned about industrial management?

Richard Muther:

I'll jump in because I feel strongly about this question. We have a situation in the existence of mankind that can be classified as either hard or "physical," procedural or "mental," emotional or "personal." Most things in the world will automatically fit into those three categories. It's very easy to look at something physical, as engineers have been doing, and measure it and think about it and design something new. It's more difficult to do that in the procedural or mental sense, in what's typically called software today, which is really hardware. Software has grabbed that name to bring it into the realm of the mind and the mental action. But the process of thinking, the process of solution finding, the process of planning needs to be analyzed by industrial engineers. Why can't we do it better, faster, more effectively?

The third category of the emotional or personal touches on the question of why can't man talk to man more constructively? Of course physically he can. But man has a heck of a time communicating with feelings from the heart to the other people of the world. And while that may not be an industrial engineering problem per se, it certainly is a management problem. In management, you always have the questions of is it a physical decision or a mental decision? A procedural decision or an emotional/personal decision? If you don't answer all those questions as a manager, you're really not a whole part of the world in my opinion.

Bill Meeker, Audience Member:

I'll add to that a little bit. The question was, "Is industrial management mature?" Given that the emphasis has really shifted more to supply chain management than just industrial management, I think the issue of maturity is not even a question. It is not mature and there is constant change occurring. From a supply chain point of view, there are no longer any barriers as to where you look for opportunities to gain improvements. The world has opened up. There are no barriers at all. So I think maturity isn't even a question – it's an inappropriate question from that point of view.

Dick Ward:

We should also look at this from the perspective of what we are managing. This brings us back to the computer and information technology and how they've affecting how we

manage things. Today we're able to collaborate much easier. We can synchronize all of our responsibilities much easier. How we acquire and share knowledge has changed dramatically. And I think that's all part of the industrial management domain.

Bill Meeker:

Industrial management includes leadership. It isn't just Chinese checkers moving things along. It's enabling somebody to see what a civilization is doing and where it's going. It's building a vision and recruiting, training, and enabling people to work together. In that sense it's a long way from being mature.

Lee Hales, Moderator:

Those are all great points. One of the things we did to commemorate RMA's 50th anniversary was to put a timeline together chronicling the improvements in industrial engineering over the last century. We discovered many interesting things during the research process from books on industrial management from the early 20th century and management handbooks from the 1930s and 1940s. So to clarify question four a bit, from that research I found that the day-to-day management of a factory was well understood a long time ago. But it seems that we have to keep relearning it and reminding ourselves how to do it. If you read the older books and replace a few choice words with our current vernacular, many could be republished today and would probably be bestsellers from Productivity Press."

In that sense, I think some aspects of what we do are mature. But I think these other points that have been brought out are very well taken. In discussing this with Dick Muther at one point, he said it very well: that the management of the physics and the physical aspects matures first; the management of the people and the process always lags behind the management or the maturation of the physical, and then the emotional follows that. That may be the best summary we'll get on question four.

Let's continue to question five, which asks, "Are Lean Manufacturing (the Toyota Production System) and Six Sigma the final expressions of industrial engineering? Is there anything more to know or do?

As someone with 35 years of experience in this profession, today it looks as if I could go on the Internet and in five days learn everything that it took me 40 years to learn – all for about $800. So is a Lean Sigma program that you can attend in a week or take as a correspondence course on the Web the sum total of industrial engineering education? Is that what's happened to our field? Are we that mature? Or is there something more?

Ben Graham:

The techniques that we're using today borrow a lot from things that we were doing 30, 40 even 50 years ago. We've added some new elements and the Lean and Six Sigma activities now are not perfect. I just read in an industry article that 70 percent of Six Sigma process-oriented projects fail. So if that's the end of the line we're in trouble.

Lee Hales, Moderator:

Well, maybe there is no discussion on this question. Of those in the audience currently pursuing a degree, how do you approach this? That on the Web it appears as though your industrial engineering education could be summed up in five days of instruction, but it's taking you 120 credit hours?

Mike Tracy, Audience Member:

I'm Mike Tracey, part time associate and general trouble-maker at RMA. I'm going to ask a question of the panel. How many of you have actually interviewed or discussed in great depth what Toyota thinks of the Toyota Production System and why Toyota keeps adding their own acronyms to the "Toyota Production System" every year?

I've found that one of the greatest misconceptions out there is that the Toyota Production System is a set of written engineering instructions or anything similar along those lines. The Toyota Production System as it relates to the outside world is really an expression of the culture of Toyota to eternally chase waste out of the system – which they have not yet succeeded in doing. They keep finding new problems to address. So within Toyota, the Toyota Production System is only a start. After 50 years they think they have some of the basics down. But the part that they haven't figured out yet is how to teach people the culture of eliminating waste in anything less than 10 years time.

Charlton Price, Audience Member:

I'm Charlton Price, a non-industrial engineer but a management consultant who has benefited a lot from industrial engineering people like Richard Muther and Bill Meeker. We've found that the Toyota Production System and other production systems are expressions of culture that originated with Edwards Deming. They represent the Deming way of looking at things and are much more than an efficiency system as you all know. It made a big difference that the Toyota system and things like that emerged from the culture as a way to do things, rather than a set of techniques independent of the culture.

Lee Hales, Moderator:

As I listen to the direction our discussion, I'll refer again to the timeline we created. In researching it and being a student of Toyota, one of the things that's discussed quite forthrightly on their Web site is the establishment of world training centers with computer-based training. One notable statistic that made it into our timeline is that they have 1,100 different courses, to try to promote and instill – rather than enforce – what they call "the one best way." That is a Gilbreth term actually. Toyota found that Kaizen events – the notion of continuous improvement evolving naturally – led to too much variation.

To me, this brings us back to the recommendations from industrial engineers 100 years ago to standardize the process. As trained industrial engineers, most of us realize that the emphasis on standardization originated with Gilbreth and Frederick Taylor before that.

But in the modern world, many people not trained as industrial engineers think that term, "the one best way," came to us via Toyota. So it's interesting to watch that cycle happen. I guess it's just human nature that we've got to keep relearning things and going over it.

Let's go to a much broader question now that I'll direct to Ben Graham, "What are the skills needed by industrial managers and engineers looking forward?"

Ben Graham:

Well, in the arena of white-collar work there is a skill that I find really lacking – it's the understanding of existing process. Today there is a lot of focus on implementing ERP or business process management solutions. But I think people still don't understand or examine the existing process before they start the ERP or BPM projects. There are good tools available for understanding that work. But typically, people only give the existing processes a cursory nod without gaining a real understanding of what is going on in the first place.

Richard Muther:

I comment on that in this way. Conceptually, you always start from the outside in, from the big to the small. If you are looking at a physical problem, you dance around it from the outside first and see what the impact of any change might be. As Ben has just suggested, you also have to understand the situation. However, we often think that a solution has to involve changing what already exists to something better. But suppose you don't have anything to start with? Then you have to begin with envisioning what could be. I think that training in this area – the ability to envision newness, new ideas, regardless of what already exists – is absent or woefully lacking at best.

Industrial engineering and industrial management, or the whole field of problem solving does not have to have a problem to start with. I think this is going to be a big change in the current century as we learn how to get to solutions that we would like to have without bothering to look at what we have. Now that doesn't mean that the solution we're going to have is going to be some idealist solution. It has to function. It has to perform. It has to solve cost problems. It has to be effective. So I'm beyond the question of looking at the problem to start with, but rather looking at the situation to start with, and the environment, and the surrounding situations, and then deciding conceptually what you would like to have and driving your solution toward that outcome. I think that's a foreign idea to a lot of industrial engineers, especially in those areas where you don't have anything to look at so you don't really know what the problem is.

Chas Scheiderer:

I think far too often industrial engineers don't achieve the solution that they've envisioned. So what are the most important ingredients to success? One simple ingredient is having the right people committed to getting the project done. You also have to understand all the internal and external conditions that can impact the solution and its implementation. Then you have to spend time studying to become the absolute

best in that specific space that you are working in. I don't think people do enough reading to become the experts that they ought to be. Finally, you need the plan and the strategy to get it done. It should occur in the order of first getting the right people, then understanding the internal and external situation, next understanding the operating system, and finally, creating and executing the strategy.

Lee Hales, Moderator:

In deference to Gerry Nadler who couldn't be here today, he would absolutely endorse what you are saying. Starting with the right people is a big thing. Just to summarize Gerry's answer to this question, he provided a list of skills industrial engineers should have, including basic sciences, physics, chemistry, biology, math, statistics, basic engineering, materials, electronics, controls, computers, data processing and IE tools. He also included modern skills like modeling and simulation, human factors, and ergonomics in addition to the traditional plant layout and material handling analysis skills. Then he closed with systems, elements and dimensions, systems thinking, architecting – sort of the "visioneering" that Richard Muther was just alluded to – management, and the role of people and politics in getting results. A lot of these skills are pretty far from the traditional engineering space. There is probably a lot of truth in his answer, but that curriculum is a full menu and it presents a challenge for those of you who are here as professors those of you that are trying to become IEs.

Charlton Price, Audience Member:

I have to make another comment from the management consultant bleachers, which is to add client relations, project management and collaborative planning to all the other skills mentioned. These skills have to be practiced. I don't think you can learn them in the classroom.

Ed Phillips, Audience Member:

Returning to Richard Muther's point about envisioning solutions, wasn't that one of the original tenants of industrial engineering? Years ago, appliance and electronics companies like Motorola would give an industrial engineer a walkie-talkie and ask, "How much is it going to cost to build this?" That industrial engineer had to visualize how the walkie-talkie would be made, what processes would be used, how many people would be required, what that factory would look like? He had to envision those solutions and be technically confident in what the processes would consist of before he could even dream of what the walkie-talkie would cost the consumer.

In the appliance industry, I can remember when it was so important to save a penny. I can remember one VP of manufacturing said he'd kick his grandmother down an elevator shaft if he could save half a cent on a coffee maker because the multiplier for a three-dollar coffee maker was $39 at retail. In that kind of environment, industrial engineers really had to know their business and how to envision solutions. I think that is missing today in most of the industrial engineers I run into. They can solve a problem you give them, but they can't develop the processes on their own.

Harvey Donaldson, Audience Member:

Let me briefly give an overview of the industrial engineering curriculum at Georgia Tech. We are the largest industrial engineering department in the country with 1,400 students, about 1,000 of them undergraduates. We're operating with a 124-hour curriculum compared to 150 hours 40 years ago. However, there are some things that I think we do very well today, probably better than any of the educators in the 1950s and 1960s. One of those things is teaching quantitative skills. Today we turn out excellent students in terms of their knowledge and skills in operations research, statistics and computer science. Another thing that is fundamentally different today is that we now provide a much broader, global educational experience for our industrial engineers. They now take foreign languages. How many of us who attended undergraduate engineering schools years ago ever attempted or were even allowed to take a foreign language? Today, study abroad programs are a key part of industrial engineering education at Georgia Tech.

Quantitative skills and providing a worldview of globalization are superior things that we're doing in undergraduate education today. Personally, I think we're doing much less well in the areas you all have just mentioned – teaching practical problem solving skills and methodologies in our curriculum. Today, operations improvement, quality control, layout methodologies and similar topics are just non-existent in undergraduate curriculums. We have also largely ceded graduate operations management education to business schools. The industrial engineering programs simply don't do that anymore. The emphasis is on the undergraduate program and Ph.D. programs, not on Master's Degree programs.

Mike Tracy, Audience Member:

One question that I haven't heard the panel answer yet is "what an industrial engineer is?" I keep hearing various people describe it differently. My undergraduate degree is in mechanical engineering. That degree covered everything from the world of plumbing, to engine design, to steam systems. But everybody here seems to be talking about industrial engineering as though it's a single discipline without sub-specialties. What do each of you think an industrial engineer really is?

Hakan Bütüner:

We all know that marketing is the main force for almost all businesses. So we should ask ourselves first what the market gap is and how we are going to fill the gap. And the solution is to find some way to innovate. Innovation is the key word here. Who is going to find the gap in the market and come up with an innovative solution that will become reality in the form of operations and management effectiveness? Unfortunately, my answer is not the industrial engineers, but maybe the engineering managers. If you take industrial engineering and industrial management and simply omit the word, "industrial," you will be left with engineering and management.

Lee Hales, Moderator:

Mike, your question takes us back to the industrial engineer Ed Phillips recalled: the person who could envision how something is going to be accomplished. My answer to your question is that an industrial engineer is a systems architect or systems engineer – and I'm using the word "system" in the broadest sense – but a person who devises a system by which a device will be made on a recurring basis, or an event will be transacted on a recurring basis.

I'll add to my answer by referencing reference Gerry Nadler's written response. Gerry said that the industrial engineering degree is the liberal arts degree of engineering. That resonates with me because I have a liberal arts degree in political science, not an engineering degree. My degree didn't have sub-specialties. We studied history, sociology, politics and geography. You were expected to become competent in these subjects, but you didn't go too deep within any one of them. You didn't become a geographer but you had to understand geography. You didn't become a public administration major but you had to understand government. I think somewhere along the line industrial engineers got caught in the trap of wanting to be all things or you needing to know all things. Since IE curriculum doesn't have sub-specialties, maybe that's part of the problem.

Les Hannon, Audience Member:

When I was running a large industrial engineering department, we employed a lot of IE graduates that we considered educated technicians. One of the biggest problems they had was selling projects to the people in charge. They had trouble securing project funding and project approvals. I don't know whether the education today is as technically focused, but how are the students being taught to compile reports and sell their ideas? It is so easy to get lost in the morass of technical jargon when explaining an engineering solution, but the people in charge may not be familiar with the terminology. To be successful, you must know who you are working for, what they expect and how best to communicate your ideas.

Dick Ward:

We have about 140 IE programs in the U.S. and some are doing an excellent job teaching the human side of the engineering discipline in addition to the technical. But Mike, was your question answered as to what is an industrial engineer?

Mike Tracy, Audience Member:

I haven't heard an answer yet.

Dick Ward:

Industrial engineering is the process by which you take the physical and mathematical sciences and engineer the highest possible performance out of an operating system, however you define that operating system. Now I'm hearing some disagreement from the

audience and seeing heads shaking left and right rather than up and down. The Institute of Industrial Engineers uses a longer definition. But I think the objective of industrial engineers is to get the best possible performance out of an operating organization or operating system.

Ben Graham:

From my perspective in an office and working with people, an industrial engineer is someone who helps people do their jobs better.

Bruce Andersen, Audience Member:

As a former associate for Richard Muther & Associates, I don't disagree with all the comments here about what industrial engineers should do or the skills an ideal engineer would have. But not every engineer can be a Renaissance man. At some point there will be too many things to learn, and IEs won't be able to do any of them well. I think that Chas Scheiderer made a key point when he talked about IEs having a broad definition of project management. I absolutely agree with that in terms of being able to take a solution and drive it through to completion. But at some point, if we expect industrial engineers to know everything, it's not going to happen.

Brian Savoie, Audience Member:

I am the vice president at RMA and I agree completely with Bruce's comment. The question I put to educators and businesses is "what is the absolute core for industrial engineering curriculum in universities?" There are many things it could cover. But what should the core be? Frankly, I think defining the core curriculum may actually provide the definition of an industrial engineer that we're seeking. I would also ask, "what should businesses be doing to further the education and development of people who come out of IE programs?" I didn't learn project management while attending Duke or Georgia Tech. I learned it at on-the-job at GE and by doing other projects. I didn't learn human interaction and how to sell a project at an engineering school, nor did I expect to. But I've learned that by practice and by working with people who are good at that. So my question to the panel is, "what level of development should businesses be responsible for teaching IE graduates?"

Dick Ward:

Businesses should make IEs responsible for things like how to sell a project and how to work effectively in teams. I think the students coming out of IE programs should know that their education is not yet over. The core engineering curriculum is in the sciences, centering on engineering statistics and operations research. Those are fundamental. To the extent that IEs can learn other skills is fine, but that responsibility comes in after the four-year degree, and once they are working in the field.

Deirdre Jasmin, Audience Member:

I think today there is a very strong need for a post-graduate degree in a specific area beyond the general IE education. I believe it's harder and harder to rise to the top of professions without a second degree, a master's or Ph.D. in something. Ongoing education also plays a role in acquiring the rest of the skills that have been mentioned.

Cerry Klein, Audience Member:

I'm Cerry Klein, head of the industrial engineering department at the University of Missouri. In academia there are pressures from both sides. Our industrial advisory boards, which represent the industry side, tell us they want our students to have technical skills like Excel. We think they are bright and talented students that can learn a lot of those things on their own. On the other side as educators, we want to teach our students to think and to solve problems. That's because most of the technical skills they have at graduation will be irrelevant in four to five years. We want to teach them the basic fundamentals so they can adapt intelligently to solve new problems.

But we also have the pressure of cost. Higher education is becoming more expensive. So we can't extend the curriculum to 150 hours and we have to pick and choose what to emphasize. Now engineering schools are trying to decide what outcomes to measure. Many schools have adopted teaching techniques that emphasize interpersonal communication. By the time they graduate, many students have made 40 to 50 presentations and written 50 reports. Their courses are more writing-intensive. This is happening across the nation, so I think a lot of educational institutes have heard what you are saying and are trying to respond. But universities still have the larger overall goal of training the individual to be able to adapt once they are in the workforce to whatever comes their way.

Lee Hales, Moderator:

Thank you for that, and now let's move on. I'm going to combine questions seven and eight. Question seven was, "Will industrial engineering exist as an academic discipline in 50 years?" And question eight asks, "Will industrial engineering exist as a sizable and well defined profession?" Do we envision those conditions still existing 50 years from now? Let's ask Richard Muther to weigh in first.

Richard Muther:

It may not be called by the same name – industrial engineering – but the activity and service the profession provides will still be taught in 50 years. I predict that the curriculum will move away from tools and techniques, which industrial engineers have tended to become infatuated over in recent years. Moving forward, I believe we need to see "the bigger picture" at the academic level.

Lee Hales, Moderator:

Gerry Nadler's written response to this question is excellent. It refers also to an article he included. I think Gerry believes that the curriculum will be interdisciplinary in nature to become closer to "systems engineering." In some ways, "systems engineering" is perhaps a better term since people always get hung up on the word "industrial" and wonder how it applies in a bank or a hospital.

Harvey Donaldson, Audience Member:

I believe that there will be industrial engineering departments at the undergraduate level as long as the market continues to pay a premium for the Bachelor of Science in Industrial Engineering degree versus a Bachelor's degree in Business Administration or Operations Management. That is true today. There is something either in the way we select our students or train our students that enables them to demand a premium in the market when they graduate. I think that as long as we continue that, regardless of what we might teach them and how we might argue about what we teach them, the market will continue to support the need for the degree.

Lee Hales, Moderator:

Our next question asks for predictions about the most significant developments in IE over the next 50 years. What do the panelists see as the most significant developments ahead?

Ben Graham:

I hope that there will be tools and more emphasis on understanding information processes and developing this part of the labor force, which overtook the blue-collar labor force 30 years ago. Still, as far as process improvement goes, I think it's still in its infancy.

Richard Muther:

Someone in the audience stated earlier that a bushel of tools and techniques does not make a comprehensive process of planning. If we get lost in tools and techniques and fail to see the future that lies in the industrial engineering of the mental process – of learning how to plan effectively – then we are going to be subjugated to has-been status. Industrial engineering will get left behind if it fails to be large enough in its thinking. If IE doesn't encompass a school of planning that teaches people how to arrive at decisions better – which is what we claim to be teaching ourselves – then we will miss the opportunity that presents itself. 300 years ago, interchangeable parts were the next big thing, then came mass production and industrial engineering. And now systematic planning is on the horizon. To me, there is a great lack of support for the science of planning. When I was on the faculty, I looked at every teaching project as an industrial engineer. I looked at teaching as an industrial engineering problem. I don't see that today in the academic world. But in the future, the trend is going to be toward the mental process of thinking about things and how to do that better, rather than the physical process of how to put things together.

Dick Ward:

I am going to say something that's probably going to bring Richard Muther out of his chair. I don't know that we don't know how to plan. I think the more critical thing is that we don't allow enough time for planning. I see some disagreement in the audience again. If you have time to plan, you are going to force the issue of looking at alternatives. I think generating alternatives is a critical part of the planning process. In most enterprises, adequate time is not allowed for the planning process and that's more the issue than how to do it.

Lee Hales, Moderator:

Let's agree that we need time and method to achieve proper planning. I want to reserve the last ten minutes because we have a room full of young people here today and question ten, "What advice would you give to a young person entering our profession today?" applies directly to them. Let's hear from the six panelists first and then from any audience members.

Richard Muther:

I'd like to challenge the young people here today by posing a question to them. How many of you think of your life as an industrial engineering project? And if not, why not? The most important project that you'll ever have is your life. It's you. You are the project. So learn how to plan it, execute it and set up how to control it and operate it more effectively.

Ben Graham:

I advise you to take pride in the work that you do and enjoy what you do.

Chas Scheiderer:

Make sure you work at a place that appreciates you and that allows for and encourages divergent thinking. Find a place that allows you to respectfully express a divergence of ideas from what your leadership may believe. The best ideas are usually those that come from a combination of ideas. I remember when I was an RMA consultant and we would come up with several plant layouts, sit down with the client and other engineers and then go through them all. Every time, the best solution came from the discussion and evaluation. It was never one that we entered the room with. So find an organization that allows and encourages that divergent thinking.

Hakan Bütüner:

I recommend that you broaden your vision of the world, learn about and be adaptive to different cultures.

Dick Ward:

I would add that industrial engineering is a great field with boundless opportunity. When we talked earlier about innovation, hopefully if you learned here today, it's that our field is anything but stagnant. The rate of change is phenomenal. Innovation is taking place across the board. If that doesn't encourage you to continue with your degree, I don't know of anything else that will.

Lee Hales, Moderator:

I think those were great summations. From a personal perspective, for those of you that are interested in manufacturing, I would second Hakan's point. Find some way to get abroad and get into manufacturing plants. Start in Mexico if that's close and easy. Go to Asia whatever chance you get. Go to Europe, go to Eastern Europe. Get into a company that will move you around and expose you to people and other cultures, plants in other locales, and the way things are getting done in other places. Along the way, you will pick up the key issues in global logistics which are what the future has in store for North America. Our future is going to be in logistics and material handling. We're going to make less and less of what we use on a day-to-day basis in North America. But we're going to have to bring it all in somehow and get it to where it's needed. So my personal perspective is go west, meaning across the Pacific and keep going until you get some perspective from the rest of the world and then look back. Are there any final comments from the audience?

Mike Tracy:

I would like to add one last recommendation. If you are going to be the agent for change and the systems improver, learn not to be complacent with anything. Always keep looking over the horizon at where you can go next, what you can do next and what you can be next. Things are always going to change, and those of you that stay ahead of that crashing wave are the ones that are going to be the most successful and hopefully the most happy in that process.

Lee Hales, Moderator:

And you get to command a premium when you are negotiating your paycheck!

Let's give a round of applause to our panelists. And thank you for being such a great audience. Some of you who came from universities, I've just met for the first time today. The rest of the group, I have the great honor and pleasure to have known for many years. So I knew we'd have some stimulating discussion this afternoon and it turned out just like I thought it might. Thank you for coming.

* * *

Responses of Dr. Gerald Nadler

- President, The Center for Breakthrough Thinking® Inc., an international consulting firm dedicated to improving the effectiveness of engineers, planners and managers.
- Former president of the Institute of Industrial Engineers.
- IBM Chair Emeritus in Engineering Management and Professor Emeritus of Industrial and Systems Engineering at the University of Southern California.
- A life-long educator; formerly on the faculties of Purdue, Washington University, and the University of Wisconsin.

Note: Dr. Nadler was unable to attend the panel due to a sudden medical situation. His written answers provided in advance were distributed to the panel members and audience. These appear below, including an attached article referenced in his answers.

1. Within North America, what are the two or three most significant developments or changes in the past 50 years of industrial ~~management and~~ engineering?

a. IM and IE are virtually separate in academia and in organizations. People with IE education may move into IM positions, but so may those with a wide variety of different backgrounds. Academia offers IM (often called operations management) in business schools while IE programs offer little of IM rudiments (e.g. marketing, strategy, finance). MY FOLLOWING COMMENTS RELATE TO IE.

b. The ascendance of the computer and OR/math/stat tools that have (1) given rise to competing professionals (e.g. OR, computer science, applied math) and (2) changed what IE topics are taught and how they are taught.

c. A loss of interest, prestige, and intellectual rigor in "classical" IE subjects (e.g. motion and time study, work study, job evaluation). Ergonomics and control topics have been enhanced by the changes noted in 1b.

d. Rise of interest in and abilities to deal with the "whole" (systems concept). This has changed the way IE is practiced and thus to redefining IE – THE ARTICLE PASTED TO THE END OF THIS QUESTIONNAIRE ALMOST COMPLETELY SHAPES MY ANSWERS TO THE REMAINING QUESTIONS.

2. What about in the rest of the world?

a. General acceptance of the separation of IE and IM. The numbers of IE academic programs and of business schools have increased significantly in developed and most of the more advanced developing countries (e.g. China, India, Indonesia). Industry has accepted the concepts enthusiastically, even while using some of the older tools and techniques (e.g. time study, work study).

b. All the new academic programs have skipped the beginning phases of IE education in the US. They have moved directly into the current analytical,

quantitative, and computerized IE version in the US. Most of the professors are US graduates who bring this view with them.

3. **Has the rate of technical innovation permanently slowed in material handling, warehousing, and factory automation?**

   This is not my area of expertise. My previous experiences in the field lead me to believe that there was a significant amount of innovation in the last 15 years. I don't believe the pace of the next 10 years will be as great, but then I won't underestimate the impact of technology on the field. Developments such as RDIF, embedded materials, nano-technology, and telecommunications can produce surprising and unexpected changes in all fields.

4. **Is industrial management (OM, business management) similarly mature?**

   The continuous referral in today's literature to the management principles enunciated by Peter Drucker might lead one to conclude the field is mature. Yet the large numbers of management programs (e.g. total quality management, ERP, performance management) that appear every year or so make it appear that changes are occurring. I think IM is relatively mature and people keep trying to game the field (e.g. Enron, World Com, Tyco) because they think they have developed a new paradigm of management.

5. **Are Lean Manufacturing (the Toyota Production System) and Six Sigma the final expressions of industrial engineering? Is there anything more to know or do?**

   NO! They are they latest in a series of techniques that are promoted as "the" salvation for IE, even though they are not. SEE ARTICLE APPENDED AT THE END OF THIS QUESTIONNAIRE.

6. **What are the fundamental technical skills needed by industrial managers and engineers?** SEE APPENDED ARTICLE FOR MORE EXPLANATION

   a. Basic sciences – physics, chemistry, biology, math, statistics

   b. Basic engineering – materials, electronics, controls, computers and data processing

   c. IE tools – human factors and ergonomics in terms of the organization of work and the design of modern work systems, modeling and simulation, financial engineering, quality assessments, especially design methods and applications

   d. Systems – elements and dimensions, systems thinking and architecting, risk and failure analysis and management, role of people and politics in getting results

7. **Will industrial engineering exist as an academic discipline and degree in 50 years?**

   Yes, most likely as Industrial and Systems Engineering (ISE) if proposal in appended article is adopted, or as applied math and OR if the current analytical

thrusts continue. It is likely that the word "industrial" is dropped since so much of IE practice concerns non-industrial type work.

An NSF-sponsored Committee on the Next Decade in IE (CONDIE) discussed in February 2006 the outcomes and themes IE should seek. Some of the major ones are large scale systems of systems, societal systems, leadership in interdisciplinary research, real problems and practical experience, and "sex it up."

8. Will industrial engineering exist as a sizeable and well-defined profession in 50 years?

Yes if the profession defines itself to achieve the purpose of "designing and improving systems." The emergence of enterprise systems engineering should be another reason for the continued existence of IE. Both perspectives recognize that an innovation and design leadership environment is a potent role for ISE. These directions are an embodiment of the hoped for outcomes and themes of the CONDIE report.

9. What will be the most significant developments in the next 50 years of industrial ~~management and~~ engineering?

Beyond the definition change suggested in the appended article, a way of thinking and acting and a process of reasoning that are holistic in perspective instead of reductionist as at the present time.

10. What advice would you give to a young person entering our profession today?

a. Are you technologically capable?

b. Do you like working with people?

c. Are you willing to take part in a life-long broad range of professional development and association activities that is necessary in today's global economy?

d. Are you willing to consider all societal sectors as potential career activities (ISE is the "liberal arts" of engineering because it prepares you to design and improve systems anywhere)?

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INDUSTRIAL ENGINEERING'S NEW "TAGLINE"

Behrokh Khoshnevis, Joe H. Mize, Gerald Nadler*, and F. Stan Settles

Overview. Like most Industrial Engineers, we are firm believers in and practitioners of the profession. Yet we, like others, have had difficulties in succinctly explaining what we do and how important it is in society. The adverse impact this difficulty has on the Institute and the profession can be stemmed if we now state that "we design and improve systems."

IIE President Allen Soyster, in his address at the May 2005 IIE Conference, presented the Institute with a Grand Challenge – what is the IIE passion, what drives the IE economic engine, and what can we be best about in the world. (Visit *http://iienet.org* for a link to **"**President Al Soyster's State of IIE presentation**.")**

The authors have been practicing and teaching IE for a combined total of well over 130 years! Yet we and many other IEs still struggle with the same questions that have haunted the profession since its inception more than 100 years ago. In addition, some ancillary questions would be more easily answered if the Challenge elicits effective responses:

- How can we convey to high school students and their career counselors what the IE profession is all about?
- How can we enhance the image of IE in the functional areas in which IEs practice?
- How can IIE better represent all of us in whatever functional area we are engaged, and better serve its members as they are faced with new challenges in an ever changing world?

President Soyster is as proud as we are of our profession and our roles in promoting it. Yet all of us recognize along with most colleagues that the responses to such questions to date have been far from satisfactory, so unsatisfactory that today IIE, and perhaps the IE profession, face, as President Soyster documented, a major crisis of existence.

Simply put, the profession must adopt a forward-looking, positive vision of itself so it can go on the offensive in establishing its basis and value and provide exciting answers to these questions. President Soyster presented a perspective that we believe will move IE and IIE significantly to the fore: "Industrial Engineering – A Profession for the 21st Century, Designing and Improving Systems."

We want to provide background for and explanation of this "tagline" or thrust statement:

INDUSTRIAL ENGINEERING CONCERNS DESIGNING AND IMPROVING SYSTEMS.

Designing: - - conceptualizing, architecting, and creating a product, process or system; a positive mode of future-based reasoning; planning and development of needed and implementable outcomes; innovating; embedding IE within all the planning and design professions.

Improving: - - recognizes that the "best" or "right" answer is never fully attained; mechanisms for continuous improvement are incorporated explicitly in the design of business systems and processes; finding efficiencies; eliminating waste; maximizing quality.

Systems: - - a set of interactive and interdependent components which act together to achieve an objective or purpose, specifically for IE those that involve human, information, and economic factors; system boundaries are situation-dependent; examples of systems defined at varying levels include (a) an enterprise system to produce goods and/or services, (b) a manufacturing plant, (c) a section within a plant, (d) a work cell, (e) a specific job; information and knowledge management system; strategic planning system; service process system; human resources management system.

SOME BACKGROUND

Three interwoven threads of background trace the path that leads to the challenges and questions about IE and IIE: Where is IE practiced, what outcomes are expected from the profession, and what techniques form the skills IEs bring to an IE practice.

Where is IE practiced?

As President Soyster noted, IE originated in manufacturing near the end of the 19th century and remained focused primarily on the shop floor until the middle of the 20th century.

Since the 1950s, the areas where IE is practiced on a regular basis have increased exponentially in all segments of society – education, financial institutions, health care, churches, think tanks, military, charity organizations, natural resource extraction, government agencies – and at all levels and in most of the functions of the entities.

Paradoxically, this explosion of areas of IE applicability has contributed to the difficulties in recognizing its value. Most people associate themselves with and "make their mark" in specific functions or areas of human and organizational concern, such as marketing, accounting, information and knowledge management systems, manufacturing, operations, public works, health care services, etc. IEs practicing within any of these arenas gain so much expertise in them that they put their IE skills at a subconscious level, and thus do not continue to identify strongly with the profession or its professional organization.

What outcomes are expected from the profession?

The motivations and stimuli at the start of IE were efficiency driven. Specific aspects of efficiency, such as performance time, motion patterns, and pay, were the focus of the pioneers. Costs were added to the efficiency mix when the initial outcomes were found to be affected by materials and inventory, and then quality was identified as part of overall efficiency. Productivity improvement and waste elimination are the latest incarnations of how the efficiency outcome is expressed.

As the arenas of IE practice expanded, many practitioners were expected to take part in earlier decision making about how the processes in the functional area were to be set up rather than only be concerned with improving the productivity and quality of existing processes. It didn't take very long for organizations to recognize that IE should be involved even in the invention, design and planning of the products and services as well as the processes to produce those outputs.

Put another way, the outcomes expected of IE should be, to paraphrase Peter Drucker, to plan to do the right things as well as develop ways to do things right.

What techniques form the skills IE bring to its practice?

Any applied profession develops and advocates a particular set of techniques, however much some of them overlap with other fields. Those in IE started with formulations of successful past practices, the time studies of Taylor and the motion analyses of Gilbreths. Various techniques have been added since then – engineering economics, quality control, statistics in general, operations research, computer programming, simulation, decision analysis, ergonomics, quality circles, and many function-specific adaptations of these, such as scheduling and production control, facilities location and planning, transportation analysis, supply chains, mass customization, and lean manufacturing. Of course, the emergence of new technologies, such as transistors, computers, fiber optics, and wireless capabilities very often change the way the techniques are defined and used.

One of the most telling characteristics of these techniques for the IE profession is that most were developed by people who did not claim they were IEs! That is, IE was "behind the curve" and often had to be pulled, sometimes screaming and complaining, into adopting most of them, especially the Operations Research techniques that were developed during World War II. Each of us is hard pressed to identify any techniques since then that arose solely in IE. President Soyster listed 14 competing professional societies, and there are more, that arose based on these techniques. This characteristic of IE techniques is a major reason IE has been unable to establish its uniqueness.

However much techniques are considered a hallmark of a profession, they "do not a profession make." Offering seminars, conferences, publications, and definitions based mainly on techniques, as is done by IIE, without an overall frame of reference for the profession, exacerbates the difficulties. The medical, architectural, and other engineering professions, as examples, have their distinctive tools, but they each identify themselves in

broader terms. Einstein noted that "The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honors the servant and has forgotten the gift." IE, similar to other professions, must foster the intuitive and creative mind and not only "honor the faithful servants."

WHAT DO OUR CUSTOMERS WANT?

Although there may be other ways to classify "customers", we will focus on two broad groups: (1) organizations that employ Industrial Engineers and (2) high school students (and their career counselors) who we would like to attract to IE.

Companies and organizations at the end of the 19th century sought efficiencies and then over the years added the other outcomes described above. Note that each of the earlier outcomes was not discarded as a new outcome was added; the earlier outcomes were just considered necessary, but not sufficient. For example, the Dell Company still seeks time efficiencies on jobs even though the change may be as small as four seconds, and lean manufacturing or lean management continues the inclusion of efficiency efforts.

Much of what organizations want may stem from the management fads of the moment that are touted as "the" answer to organizational ills. The "flavor of the month," such as automation, total quality management, best practices, six-sigma, and lowered levels of decision making, eventually loses its top billing while still remaining a part of organizational requirements for productivity and quality improvement, or efficiency. These will remain important, yet there is a perceptible shift in emphasis toward being competitive and a market leader beyond only cost, time, ROI, and quality measures.

The outcome marker for this new emphasis is called "innovation". It is an important shift to include with the broadly incrementalism nature of productivity and quality improvement, as epitomized by the innovation initiatives added by Jeffrey Immelt at the General Electric Co. when he succeeded Jack Welch. It is a word that impacts and could be sought in many functions of an organization; after all, innovation can lead to radically changed functional areas, such as marketing, distribution, finance, and customer relationships as well as new products, manufacturing processes, and service delivery methods.

The issue for IE is thus "simple": Let's put IE in a leadership role for designing and improving systems via breakthrough innovations, that achieves in an integrated way all the outcomes our organizational customers want, whether for-profit, not-for-profit, or governmental.

High school students trying to decide what program to take at a university would now be presented with a framework that they can understand, where they can apply their science and math skills within the societal work setting they choose, that lets their very often expressed entrepreneurial interests develop, and that provides a major insight to the reality that technology needs integration with people and social perspectives to become workable for society. To us, providing this perspective to a high school student is needed and should be considered by the profession as a "no-brainer."

WHAT IE AND IIE CAN BE

"Industrial Engineering Concerns Designing and Improving Systems" is intended, first as a statement of the profession's mission, and, second as the underlying rationale for IIE's strategic direction (attracting and retaining members). This thrust statement offers the following important advantages to IE and IIE, relative to the current official definition:

Length and Clarity of Thrust Statements or Definitions
Designing and Improving Systems consists of only four words, whereas the current definition of IE is lengthy and confusing. The elaborations of the three key words are offered to explain their intent and to speak directly to the fundamental meaning and relevance of IE's role in the world. The explanations would be used to answer questions likely to arise when someone wants clarification of one or all of the key words. In written format, the italicized statements near the start of this article would allow readers to seek whatever elaborations they may want.

Marketability
Because the expressions in our thrust statement elaborations are enlightening and understandable, we believe that they will better serve the IE profession and IIE in our on-going efforts to attract high school students, to convince graduating IEs to join IIE, and to retain IIE members.

Education
The emphasis on designing as well as on improving should convince educators to teach IE courses with primarily a design perspective, and even to set up design-oriented IE curricula. Emphasis in a curriculum and in teaching techniques with an analysis orientation is limiting.

Organization
The proposed thrust statement provides a sound rationale for organizing useful publications for all of our members, for developing attractive and meaningful seminars presented in a context of the larger purposes of the profession.

Public Relations
The proposed thrust statement provides a more understandable description of IE's role in the world. Consequently,

- We can better communicate with the general public and we can present a more persuasive case for IE to managers and executives.
- It is a recognizable and direct way of explaining the profession to the public, constituencies, organization human resources departments, and high school students.
- It introduces a continual emphasis of creativity diversion and outcome-based convergence in all IE activities, and is a positive rather than defensive way of involving people in developing outcomes.
- It provides an ability to incorporate diverse techniques and bodies of knowledge, and establishes a firm role relationship with other disciplines, including other branches of engineering.

- It can serve as a framework for developing major topics for future research that advance the profession, for developing design oriented techniques, and is a way of portraying a major IE presence in all the functional areas of an organization.

The purpose of this article is to support and explain President Soyster's "tagline" or thrust statement for the IE profession in the 21st century. The authors believe it is an improvement over the current official definition. We encourage practicing IEs, IE educators and IE students to assess these ideas and cooperate in a plan of moving the IE profession to its appropriate role in society.

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Responses of Chas Scheiderer

- Distinguished career in warehousing, materials handling, and transportation.
- Formerly Senior Vice President – Logistics, Best Buy.
- Formerly with Payless Shoes and Quaker Oats.
- Extensive experience with performance measurement, leadership, teamwork, and personnel development.
- Degreed industrial engineer with MBA.
- Former RMA associate – our most distinguished in industry.

1. Within North America, what are the two or three most significant developments or changes in the past 50 years of industrial management and engineering?

Having the ability to have a global real-time picture of the entire supply chain is the most amazing to me. A planner in a remote location has the ability to know the status of all elements of any process. He may have the ability to look up to the beginning of the supply chain to manage the flow of raw materials and forecast needs based upon current internal and external conditions. The integration of the available technology through enterprise information systems makes full information possible to anyone who needs to know.

The recognition of the people doing the work is of significance as well. This has been showing up in leadership texts for decades, but it has taken a front seat with Lean-Sigma. We aren't going to get the best end-product unless we empower people to make decisions in the areas they influence.

2. What about in the rest of the world?

Is there a difference?

3. Has the rate of technical innovation permanently slowed in material handling, warehousing, and factory automation?

Industrial engineers are discovering new challenges everyday. Changes in the environment, cost and energy and the continuing competitive pressures for immediate satisfaction will continue to create new problems. Innovation is generally incremental. Often, it doesn't seem like much is changing in material handling or factory automation until you compare facilities that are a few generations apart. Think about a carton sorter installed in the early 90's against one made today. The current sorter is quieter, more reliable, integrated into the WMS, and it tells you when it needs maintenance.

RFID is just beginning to become available. This technology will revolutionize the factory and the life cycle management of durable goods.

The application of information technology is still expensive. Warehouse Management System and warehouse automation applications are readily

found in businesses handling high volume and/or easily handled products, but applications for hard to handle or bulky products are too expensive. As we apply more integrated solutions through enterprise systems we will be able to broaden the applications to a wider array of products.

4. Is industrial management similarly mature?

Technological innovation has not slowed, nor is industrial management mature. Today's industrial manager needs to know a great deal more about a specific process or business while mastering an understanding of external pressures. Businesses are still trying to figure out how to develop and retain the right people.

5. Are Lean Manufacturing (the Toyota Production System) and Six Sigma the final expressions of industrial engineering? Is there anything more to know or do?

The industrial engineer always finds a better way. Already, Lean-Sigma combines the analytics of Six-Sigma with the empowered workers of Lean to find a better way.

6. What are the fundamental technical skills needed by industrial managers and engineers?

Industrial managers will do well if they master the skills taught to industrial engineers such as engineering, mathematics, finance human relations and information systems. Industrial engineers need to take the general skills they learn and apply them to their work and develop a high degree of expertise in the field they are working in. Both the manager and the engineer need to have a competency to collaborate.

7. Will industrial engineering exist as an academic discipline and degree in 50 years?

Included with answer to Question 8 below.

8. Will industrial engineering exist as a sizeable and well-defined profession in 50 years?

I can see why some are concerned that I.E. may disappear into other disciplines because they are seeing a decrease in the number of pure industrial engineering departments in businesses. I don't share that concern. Industrial engineers are finding success in all areas of business. Their skills are crucial to the success all across the enterprise.

I am most familiar with the retail industry. Twenty years ago the retailer would have traditional industrial engineering positions in the distribution center. The IE's would be responsible for labor planning, labor standards and capacity planning. In addition, the more advanced retailers were using IE's for quality assurance and SKU analysis. IE's were just becoming to be

appreciated for what they could offer in store labor management and projects in distribution. Twenty years ago the IE's were infiltrating the business.

Now, the large retailer will be using IE's to integrate their supply chain, manage simulation studies for network design, implement inventory management systems, and create retail operating (labor) models. IE's will be part of the business process design and LEAN-Sigma initiatives. The IE is becoming ubiquitous in the organization.

It is difficult to think of an industry where IE's are not needed. There has been a tremendous growth in all of the service industries in addition to the traditional manufacturing and healthcare applications of IE's.

Some schools are modifying their names (e.g. industrial and systems engineering and industrial engineering and operations research). The name change is unnecessary; IE includes it all. I believe the discipline will survive and grow. The business schools have survived even though there is no department in the organization called "Business."

9. What will be the most significant developments in the next 50 years of industrial management and engineering?

We could ponder this for hours. I think we have only seen the beginning of globalization and the "flattening" of the world. Information and technology will be global. The futurists are telling us that our competitors will be able to achieve instant global scale to leverage their innovations.

10. What advice would you give to a young person entering our profession today?

Industrial engineering studies teach the engineer something about almost everything. Eventually everyone needs to specialize. I suggest that the young person make sure they make a conscious choice in what they specialize in. Delay until you are sure.

I think the following habits are important for continued success.

- Confront Reality-Sometimes the facts will be different than what your boss would like them to be. Stick to the facts. Don't be intimidated to go along with an idea if you think it is wrong. You will get more respect if you learn how to, respectfully, voice a divergent opinion.
- Learn how to navigate from 500 ft. to 50,000 ft. Learn how to describe complex problems simply, but understand the complexity.
- Build and practice personal habits: Ask probing questions; read and build-up your knowledge in your field; learn how to present a vision.
- Build your collaboration skills. When working with others, make sure you neither dominate nor withdraw.
- Trust your instincts.

Responses of Dr. Richard Ward, P.E.

- Executive Vice President-Professional Development, Material Handling Industry of America -- engaged at the center of the worldwide material handling industry.
- B.S., M.S. and PhD degrees in industrial engineer;
- Former professor and life-long educator; internationally-known as a leader of short courses and seminars on inventory and supply chain management, warehousing, and material handling.
- Past director of the Institute of Industrial Engineers' (IIE) Transportation and Distribution Division.
- Active member of APICS and NSPE.
- Member of the College-Industry Council on Material Handling Education.

1. Within North America, what are the two or three most significant developments or changes in the past 50 years of industrial management and engineering?

a. The broadening of the skill set required of graduating industrial engineers: e.g., work measurement and simplification, OR, statistics, ergonomics, QC, manufacturing processes . . . material handling and facility planning.

b. The ever deepening / broadening of the practice domains for IEs outside of the classical (manufacturing) industries: e.g., health care, banking and finance, transportation operations, warehousing and distribution.

c. The disbanding of large corporate (centralized) IE departments.

2. What about in the rest of the world?

a. The spreading of the IE gospel to the rest of the world, particularly to the developing countries.

b. Because of its global impact, the internet fits best here, versus just North America, to facilitate collaboration, synchronization, and knowledge acquisition and sharing.

3. Has the rate of technical innovation permanently slowed in material handling, warehousing, and factory automation?

An across the board . . . NO! In fact I do not believe it has slowed at all. And I wouldn't even classify it has mature. It may not always be obvious, but change and innovation is everywhere, in many cases driven by controls and the information revolution, but also by a lot of cleaver engineering.

4. Is industrial management similarly mature?

a. In that the emphasis has shifted to supply chain management concepts, I would have to say NO, it is not similarly mature. From the supply chain view of things, there are no longer any artificial barriers to where you look for improvements in operations.

b. Another example is the growing emphasis on financial engineering as an application domain along with tools suited to that environment.

5. Are Lean Manufacturing (the Toyota Production System) and Six Sigma the final expressions of industrial engineering? Is there anything more to know or do?

a. Probably not the final expression. However, Lean and Six Sigma are nothing more than a new label applied to the old principles of traditional scientific management and industrial engineering; i.e., work measurement, the elimination of wasted motion and work, and quality control, with a strong measure of marketing (hype) thrown in for good measure.

b. In terms of more to do . . . I believe environmental consciousness and sustainable practices provides a lot of room for industrial engineering to make its mark in ways it has not yet done.

6. What are the fundamental technical skills needed by industrial managers and engineers?

At the very least a knowledge and appreciation of engineering statistics, operation research tools and modeling, and ergonomics.

7. Will industrial engineering exist as an academic discipline and degree in 50 years?

No, at least not by that name.

8. Will industrial engineering exist as a sizeable and well-defined profession in 50 years?

NO, at least not by that name!

9. What will be the most significant developments in the next 50 years of industrial management and engineering?

CAD like systems to support the modeling, analysis and design of operating systems versus isolated pieces and parts. A question that arises every two years at the MHIA / CICMHE international research colloquium is whether there is enough science to the field of material handling to underpin the creation of CAD based systems.

10. What advice would you give to a young person entering our profession today?

It is a great field with boundless opportunity, where the human factor in the operation of systems is like no other engineering field. I say this despite my answers to 7 and 8, above. I am not hung up on Industrial being the modifier to engineering. In fact the profession needs to be re-engineered in terms of how it is defined, marketed and perceived.

Responses of Dr. Ben S. Graham, Jr.

- Chairman, The Ben Graham Corporation (a training, consulting, and software organization.)
- Fellow of the Institute of Industrial Engineers
- Recipient of the Jo Warner award, the highest award of the Business Forms Management Association
- President's Award and the Mogensen Bronze, the two highest awards of the Improvement Institute.
- Recognized authority on process improvement.
- Personally trained more than 30,000 people in the United States and abroad.

Note: Dr. Graham was unable to attend the panel due to an unavoidable obligation. He provided written answers to the questions below. Dr. Graham's place on the panel was ably filled by his son, Ben B. Graham, President and CEO of the Ben Graham Corporation. Ben shared the same position and points of view described by his father below.

1. Within North America, what are the two or three most significant developments or changes in the past 50 years of industrial management and engineering?

I feel that the two most significant developments affecting industrial management and engineering are;

1. The broad recognition of and acceptance of "process" as a crucial focus in work improvement.
2. The acceptance of and increasingly effective use of employee teams in work improvement.

5. Are Lean Manufacturing (the Toyota Production System) and Six Sigma the final expressions of industrial engineering? Is there anything more to know or do?

No! Lean and Six Sigma contain elements that are fresh and others that were done before. Each new package that has come along includes a certain amount of fresh along with repackaging and shift of emphasis. With respect to more things to know and do, I expect in the future we will see increasing emphasis on visibility and flexibility through the use of computers in ways well beyond our current capabilities.

7. Will industrial engineering exist as an academic discipline and degree in 50 years?

See answer to Question 8.

8. Will industrial engineering exist as a sizeable and well-defined profession in 50 years?

The name may change but it will be there.

10. What advice would you give to a young person entering our profession?

1. Take pride in your work and enjoy it.

Responses of Richard Muther, PE, CMC, PCMH

- Founder, Richard Muther & Associates.
- Degreed industrial engineer; honorary doctorate from Lund University.
- More than 50 years of consulting and training assignments on five continents.
- Developed and taught the first-ever course on mass production methods (M.I.T. 1942). Authored first text in America on Production Line Techniques (1944).
- Author of 14 books translated into more than 20 foreign-language editions; author of more than 100 technical papers and handbook chapters.
- Co-founder and Past President of the Association of Professional Material Handling Consultants.
- Founder and Chairman, Institute of High Performance Planners (IHPP).
- Developer of the High Performance Planning model and Planning by Design -- systematic methods for better planning in all walks of life.
- Creator of Systematic Layout Planning
- Recipient of the Gilbreth Medal for his outstanding contributions to industrial engineering.
- Recipient of the Reed-Apple Award, the Don Francis Award, and several other awards for contributions to the field of materials handling.

Comment: May I consider this as applying to "Industrial and Management Engineering?"

1. **Within North America, what are the most significant developments or changes in the past 50 years of "industrial management and engineering?"**

    a. The move to systems analysis and the computer

    b. The recurring shift in definition, in meaning, in terminology of "industrial engineering", as it reaches for its place, its recognition, its science.

2. **What about the rest of the world?**

    The same as l a and l b above, plus a more worldly appreciation for systemization of the whole planning process, as compared with particular tools and techniques.

3. **Has the rate of technical innovation permanently slowed in material handling, warehousing, and factory automation?**

    The rate may be slower but technical innovation will never stop -- "nothing happens without movement."

4. **Is industrial management similarly mature?**

    No. The physical (the visible, tangible) aspect of industrial management may be maturing, but it's mental (the procedural, process) aspect and its personal (the emotional, service) aspect is far from maturity.

It is easier to "see" the physical aspect of things, so they tend to arrive and mature earlier. The softer mental aspect" and the sensitive emotional aspect arrive and mature later. So, in the whole view -- hard, soft and sensitive -- management still is a long way from maturity.

5. **Are Lean Manufacturing (the Toyota Production System) and Six Sigma the final expressions of industrial engineering? Is there anything more to know or do?**

   There is much more to know and to do. The whole area of systemization of the planning process -- of improving the way we improve things -- has barely been touched.

   - How to see -- to observe, to envision, to discern
   - How to plan – to understand, to devise, to decide.

   These are skills yet to be developed and accepted, and they are a long way from the "tools and techniques" with which we continue to get infatuated.

6. **What are the fundamental technical skills needed by I & M Engineers?**

   How to measure (at all levels); How to plan; How to decide; How to work with others involved in contributing to, affected by, and approving of your work.

7. **Will industrial engineering exist as an academic discipline and degree in 50 years?**

   Probably not by that name, unless there is a more definitive clarification of the term "industrial engineering."

8. **Will I. E. exist as a sizeable and well-defined profession in 50 years?**

   Hopefully. But I. E. is still too oriented toward "tools and techniques", while Systems Engineering and Project Management are moving ahead without us.

9. **What will be the most significant developments in the next 50 years for I & M Engineering?**

   The most significant development in the next 50 years will be Systematic Planning.

   What interchangeable parts was to the 19th century, and scientific management was to the 20th century, Systematic Planning will become in this 21st century.

   We push teams together; we create hot new buzzwords; we know that planning is fundamental to all we do; yet we have been woefully slow to

recognize that if we are to have better coordination, better communication, and better cooperation, all of us need to be "on the same page."

"A bushel of tools and techniques -- helpful as they may be -- does not make a comprehensive process of planning."

10. What advice would you give to a young person entering our profession?

2. Generally: Think broadly and with diversification.

   Specifically, have a multiple-careers strategy that helps you build a gameplan that brings the future to you more effectively and with more comfort.

   Look at your life as the most important I.E. project you will ever have -- plan it; install it; and have a way of ongoing improving of it.

About Richard Muther & Associates

Established in 1956 by Richard Muther, our firm has achieved an international reputation as planners of profitable industrial plants, warehouses, office and service facilities. Operating in the broad field of industrial management and engineering, we have experience in all aspects of facilities planning and operations improvement. Our services are delivered through leading-edge consulting, training, and research.

RMA consulting projects are conducted on the principle of *"helping the client help himself."* Using our proprietary, systematic methods, we enable client teams to get better results in record time. And over the course of an assignment, clients master our approaches for their future use. When needed, we will collect data, perform analyses, and make presentations for approval, but our preferred role is to organize, advise, coach, challenge, show by example, and audit the work being done. This keeps your investment low and builds the confidence and skills of your personnel. Our success rate on hundreds of assignments attests to the wisdom of this approach. We assist in the following activities:

- Plant & warehouse layout
- Material handling analysis
- Planning for lean and cellular manufacturing
- Master site planning
- Office space planning
- Site location & selection
- Long-range planning & facilities strategy
- Consolidation & relocation planning

RMA training courses are conducted in-plant and through leading universities and trade associations. These have been attended by thousands of managers and engineers in 20 countries of the world. Each work course is based upon one or more of our systematic, step-by-step techniques. We offer formal certification in our more popular methods, and license our materials for continuing use by qualified and certified instructors. We currently offer in-plant seminars on more than a dozen topics. Among the most popular:

- Warehouse & Distribution Center Layout
- Systematic Planning for Manufacturing Cells
- How to Plan for Rearrangement & Expansion
- Long-Range/Strategic Planning of Industrial Facilities

RMA research projects have included a number of original surveys on management and engineering practices. We also arrange benchmarking and study missions to help our clients improve their facilities management practices.

Our research has resulted in the publication of 9 books, with translations into more than 20 language editions. We have authored over 100 technical papers and presentations, and a dozen chapters for handbooks and encyclopedias. Our associates have served as guest lecturers at the Massachusetts Institute of Technology, Georgia Tech, The Swedish Royal Institute of Technology, The National University of Singapore and several other universities.

Members of our firm have been recognized with citations and awards from leading institutions and professional societies including: the Materials Handling Award of the Society for the Advancement of Management; the Honor Award from the Materials Handling & Management Society; the Engineering Citation Award from the Society of Manufacturing Engineers, and the Gilbreth Medal for outstanding contributions to industrial engineering.