INDUSTRY DIRECTIONS

***Industry Week* Best Plants**
1998-2002 Analysis
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The MES Performance Advantage: Best of the Best Plants Use MES

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Executive Summary

Based on a thorough analysis of *Industry Week* Best Plant winners and finalist data over a four-year period, there is conclusive evidence that Manufacturing Execution Systems (MES) provide considerable performance advantages to plants that use them over plants that don't use MES.

Profitability

Performance is characterized by profitability, and plants using MES have improved profitability by four times as much as those not using MES. (Table to right.) Profitability is based on three critical plant-specific performance factors. These are productivity, process improvement and personnel performance – all captured in the Best Plant survey and benchmark database. The analysis shows that plants using MES are outperforming those that don't use MES – and improving performance faster – in all of these key performance areas. This report analyzes these areas in greater detail.

Measure	Plants Using MES Edge
Profit improvement	
% Change	400%+ higher gains – 3 yrs.
Productivity	
Productivity	84% higher revenue/square foot 32% higher value-add/employee 10% higher sales/employee
Productivity Improvement	630% greater improvement in revenue/square foot 70% greater improvement in value-add/employee 200% greater improvement in sales/employee
Cost reduction over 3 yrs.	34% greater cost reduction
Energy Consumption reduction	57% greater energy reduction
Process Capability	
Process Capability	11% better Cpk – 2 vs. 1.8
Yield improvements	15% greater improvement
Cycle time reductions	37% greater mfg. cycle time cuts; 22%+ order-to-ship
Employee Effectiveness	
New employee training time	78% as much training needed

Table 1: Best Plants Using MES outperform and improve faster than Best Plants not using MES. This uses mean values for each group, and improvements over previous 3 years to award or finalist status.

Productivity

Plants using MES have higher productivity and have improved operational productivity more rapidly than others over the previous three years. (Table 1.) Plants with MES were able to reduce costs more dramatically than plants not using MES, including manufacturing, product and energy costs.

Process Improvement

Plants with MES have higher process capability and larger yield gains. Furthermore, plants using MES have a greater reduction in cycle times and are more advanced in developing a true build-to-order model to meet JIT demands.

Employee Support

New employees require less training in plants that use MES, and training for all production personnel rely more on on-the-job training and less on classrooms.

Regardless of the plant size, industry or process type, other software systems or improvement initiatives, plants using MES showed stronger performance than others. Those using ERP, Six Sigma, Lean Quality and Demand Flow Scheduling techniques – as well as plants under 500 employees – all show benefits from using MES.

MES provides a clear performance advantage to plants: in profitability, productivity, and the ability to improve on key cost and customer service metrics. Based on this study of *Industry Week*'s award winners, the best of the Best Plants use MES.

Study Background & Methodology

Rockwell Automation contracted with Industry Directions in late 2003 to study the use of MES in the *Industry Week* Best Plants winners and finalists. The goal was to understand the performance of plants using MES vs. those not using MES.

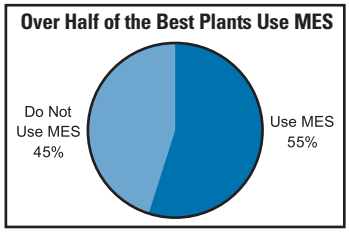

Figure 1: 58 of the 106 Best Plants use MES; this is far above the average in manufacturing industries.

We used the *Industry Week* Best Plants Benchmarking Database Version 3.0 for this research. This database includes information about every award winner and finalist between 1998 and 2002 – 106 companies in total. The database includes all responses to the 237 questions on which these companies were judged to be the top performing plants in the United States of America.

This research compares responses between the 58 plants in the database that indicate "extensive use of MES" and the 48 that do not. (Figure 1.) We will refer to these as "plants that use MES" and "plants that do not use MES." In every case, we studied mean responses for the two groups.

The definition of MES from the Manufacturing Enterprise Systems Association, MESA International follows:

"A Manufacturing Execution System (MES) is a dynamic information system that drives effective execution of manufacturing operations. Using current and accurate data, MES guides, triggers, and reports on plant activities as events occur. The MES set of functions manages production operations from point of order release into manufacturing to point of product delivery into finished goods. MES provides mission critical information about production activities to others across the organization and supply chain via bi-directional communication."

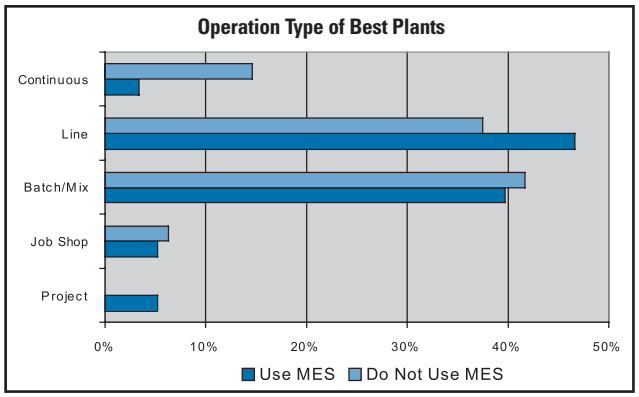

Figure 2: Every major category of production is represented in the Best Plants database. In every case, some portion uses MES. Every project-based finalist uses MES, while fewer continuous report using MES, as it is often embedded in the control systems.

We also compared results within industries and operational types. (Figure 2.) The industries represented in the Best Plants study are aerospace, automotive, electronics, high sanitation, metal forging/casting/stamping, plastics and other. The sample sizes in each industry are not adequate to generate statistically significant results. In each industry, some plants use MES. By operational type, all project-oriented plants use MES; and some of every other type use MES as well.

While the relatively small number of respondents in this database limits the amount of cross-tabulation that yields statistically significant data, the findings are clear. MES enhances plant performance – even among the country's Best Plants.

MES Profitability Advantage

This study set out to examine whether production facilities using MES enjoy performance advantages over other plants. The findings clearly indicate that they do. And perhaps most significant – given that every production plant is unique – plants using MES have improved more dramatically than their counterparts that do not use MES extensively.

One of the first very simple measures by which to recognize whether MES leads to top performing plants is to review whether these **Best Plants use it**. Of the 106 companies in the *Industry Week* Best Plants Benchmarking Database 3.0, 58 use MES while only 48 do not. This 55% of Best Plants is significantly more than the proportion of plants overall in the US that use MES.

Within that group of 106 best plants, we then examined performance of plants using MES vs. others. **Profitability** is a premier measure of success for most companies. While the study does not include raw profitability numbers it does ask about improvement. Plants using MES improved profitability four times as much in the three years previous to submitting the surveys than plants that do not use MES (350% vs. 86%). (Figure 3.)

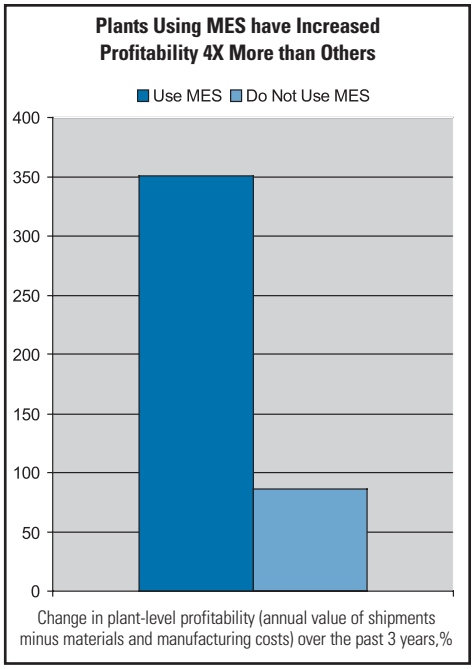

Figure 3: Plants using MES have improved their profitability significantly faster than those not using MES. This is the result of many MES benefits.

This astonishing difference in the rate of profitability improvement from companies using MES derives from faster improvements in a number of specific areas of productivity and process capabilities. A factor that appears in this data as well as other current research is that MES has a major impact on the culture in production plants, and may encourage production employees to be more proactive in identifying improvements. So the enhanced performance of plants that use MES appears in areas that impact productivity, processes and people.

It's interesting to note that ERP use is higher (72.4%) among those that use MES than those that do not (60.4%). While ERP is sold as a comprehensive manufacturing system, very few plants have found it to be effective in assisting plant personnel. Among Best Plants using ERP, the 59% with MES as well have improved profitability 4.3 times as much over 3 years – 413.3% vs. 96.2%. ERP helps plan manufacturing, and shop floor control modules can help oversee it, but managing and improving production execution requires special detailed functionality that only MES provides.

Productivity

To drive higher return on plant assets, companies are constantly striving to improve operational productivity. All of the plants in the *Industry Week* Best Plants finalist lists have achieved favorable productivity or they would not have been selected. However, this research indicates that those plants using MES are more productive and have improved productivity faster than those not using MES.

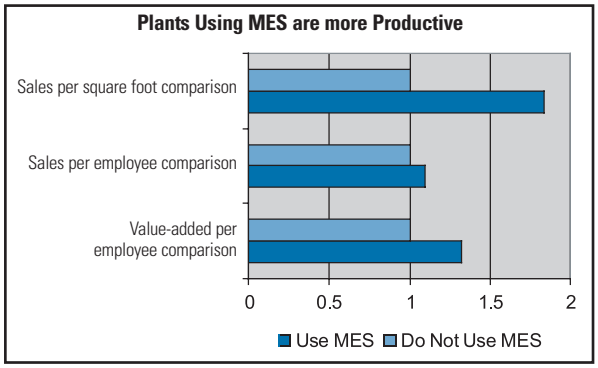

Figure 4: Plants using MES are, on average, more productive than plants that do not use MES. The distinction is particularly strong in sales per square foot of floor space, because this is the one area where both process and discrete industry plants showed an advantage for MES users.

Current plant productivity is the first question to examine. Plants using MES have higher productivity than those not using MES by all three measures included in the *Industry Week* Best Plants survey: sales per square foot, sales per employee, and value-add per employee. (Figure 4.)

Naturally, productivity growth is a key driver of growth in profitability. Here again, plants using MES showed a clear advantage over those not using MES. (Figure 5.) **Productivity growth** over the prior three years ranges from 70% higher to over six times higher for plants using MES than plants not using MES, by metric. Those using ERP found MES an even greater boost to productivity growth, with results 2.2, 3.3 and 6.6 times as great for those using MES together with ERP, compared to those using ERP but not MES.

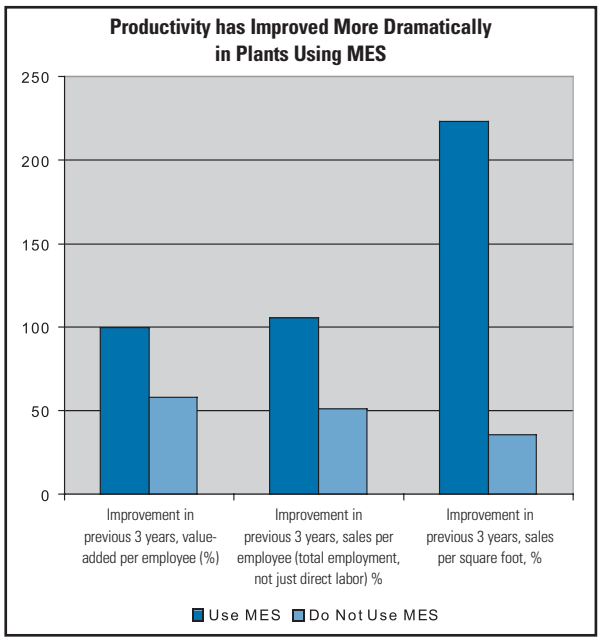

Figure 5: Plants using MES have improved productivity more rapidly than others, in some cases six times as fast over three years.

One of the keys to improvement, as many companies implementing Six Sigma and other programs have discovered, is having accurate, detailed data to identify the root cause of problems. MES helps provide that type of production data. Further, MES helps reduce errors that waste materials as well as employee and production equipment time. Over 58% of those with Six Sigma initiatives use MES as well. (See p. 13 for more on Six Sigma users in this study.)

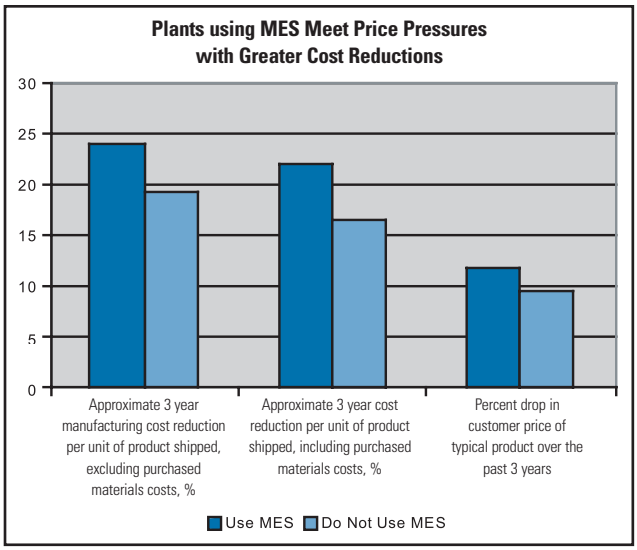

Figure 6: When customer prices drop dramatically, Best Plants drop their manufacturing costs even more. Plants using MES had more price pressure and also managed to reduce costs more dramatically.

One of the most significant challenges facing most manufacturing companies – those with Best Plants and others – was the US and global economic downturn. Those who won the Best Plants Award in 2000-2002 were particularly faced with a need to cut costs in order to make a profit, as prices fell. In many industries such as electronics and automotive, supply cost cutting is a perennial need – but nearly every manufacturing company has faced price pressures over the past few years. To maintain healthy profits, this means cutting costs.

Again, those using MES have managed to outperform those not using MES. (Figure 6.) While their customer prices dropped more, their **cost reductions** were also greater. This data suggests that companies in industries that need to make regular improvements in costs and productivity to compete effectively should consider evaluating MES. MES offers a strong platform of data and operating support from which companies can continuously improve operations.

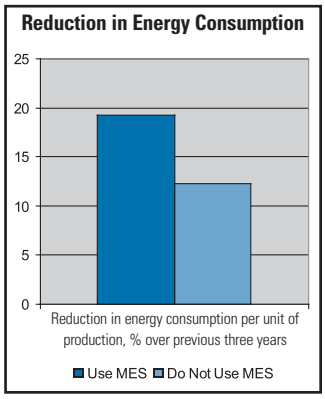

Figure 7: Plants using MES have reduced their energy consumption by 57% more than those not using MES.

Another aspect of productivity where MES appears to provide a significant boost is in plants' ability to **reduce energy consumption** per unit of production. (Figure 7.) All of the best plants managed to cut energy consumption, but there is a 57% difference. Plants not using MES achieved a 12.3% reduction compared to a 19.3% reduction for those using MES. This can most likely be attributed to MES core capabilities:

- Unified plant wide view of production that leads to greater overall efficiencies
- Operator support to reduce errors and waste
- Detailed data to track down root causes when a problem arises

In process and mixed mode industries, where energy consumption is often a larger cost, the reduction is even greater. Process plants using MES achieved a 9.8% reduction in energy consumption per unit of production, while those not using MES achieved a 5.5% savings in the previous three year period – a 78% difference.

In an era where return on assets (ROA) and operating costs are critical metrics indicating company financial health, top executives will be looking for ways to enhance productivity. This study of best plants shows that MES does enhance the rate of performance improvements that production facilities can achieve.

MES Works with Demand Flow & Lean

Among the Best Plants, 31 use Demand Flow Scheduling extensively and 34 use three lean techniques for quality (Poka-Yoke, 5S, and Plan/do/check/verify). Among those using Demand Flow Scheduling, nearly two-thirds also use MES. And nearly 56% of the Lean technique practitioners use MES.

Beyond using MES, these plants appear to enjoy some benefits over those that employ lean or demand flow scheduling without MES. (Table 2.) Productivity gains are particularly dramatic – and productivity is higher in those using MES with Demand Flow Scheduling. Cost, cycle time and lot size reductions are dramatically greater for those using MES with Lean Quality techniques.

Measure	Demand Flow Schedule Edge with MES	Lean Quality (P-Y, 5S, PDCV) Edge with MES
Profit Improvement	578%+ higher gains – 3 yrs.	367% higher gains – 3 yrs.
Productivity		
Productivity Improvement - square foot - value add/employee - sales/employee	 13.63X: 394% vs. 28.9% 7.57X: 208% vs. 27.5% 7.96X: 204% vs. 25.7%	 387%: 97% vs. 25% 28%: 30.8% vs. 24% 44%: 41.1% vs. 28.6%
Manufacturing cost/ unit reduction over 3 yrs.	35% greater unit cost reduction 21% vs. 15.4%	45% greater unit cost reduction 27% vs. 18.5%
Lot size reduction over 3 years	28.4% more: 56.6% vs. 44%	Over twice as much: 60.5% vs. 29.6%
Average overtime/week/ production employee	75% as much: 4.2 vs. 5.7 hours/week	69% as much: 3.4 vs. 4.9 hours/week
Process Capability		
Customer reject rate	<50% as many ppm	85% as many ppm
Manufacturing cycle time reductions	16% greater cycle time reductions	65% greater cycle time reductions

Table 2: Companies using MES in conjunction with their Demand Flow Scheduling and Lean Quality initiatives show some marked benefits.

Some of the core goals of Demand Flow and Lean appear far more achievable for those using MES, too.

- In the Demand Flow community, WIP turns are three times as high for those using MES. Supplier initiatives appear to be more fruitful, with a higher percentage of supplier orders on-time, greater price reductions on A items, and wider supplier management of inventories.
- In Lean plants, 10 times as much inventory is managed on site by suppliers; three times as many deliver to the point of use in the plant. Warranty costs are only 28.5% as high, at 0.2% of sales. Finished goods inventories have dropped 43 times as much (by 8.6% vs. 0.2%) over three years – while volume through these plants was up over 200% on average.

Process Performance

Overall plant productivity rests on effective processes. In the Best Plants survey, a range of questions about yield and cycle times reveal some interesting differences between plants that use MES and those that do not. In general, plants using MES have statistically equivalent or slightly lower scores for process metrics. However, they still show greater improvement against those process measures.

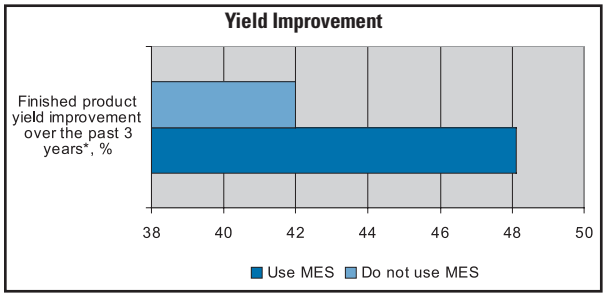

Figure 8: Plants using MES have improved yield more dramatically over the prior three years.

The mean **process capability**, or Cpk, is higher for plants using MES than those not using MES. Those using MES have an average Cpk value of 2, compared to 1.8 for plants not using MES. Despite that, first pass yield is nearly identical in plants using MES and plants not using MES. That suggests that plants not using MES put in some extra effort to achieve their first pass yield, which appears in more overtime on average per week, and less machine availability. As with nearly every other metric, plants using MES have improved yield more rapidly than those not using MES. (Figure 8.) They have also **reduced scrap and rework costs** more – 46.3% over three years versus plants not using MES at 39.8%.

Operating Equipment Efficiency (OEE) for major lines is similar. Those using MES are at 83.4% mean, while plants not using MES are at 85.8%. The median is exactly the same, at 86.8%. Capacity utilization (total annual production divided by stated or designed equipment capacity) is also nearly identical at plants using MES – 75.8% vs. 78.2% for those not using MES.

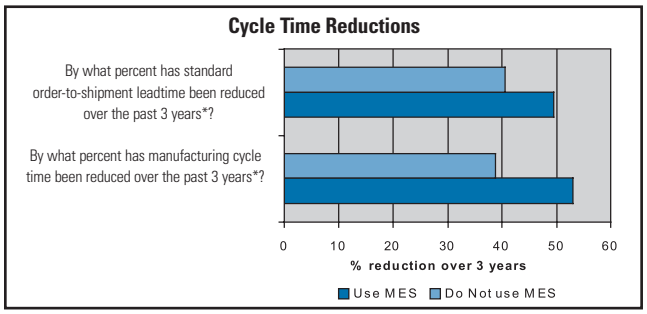

Figure 9: Plants using MES have reduced both manufacturing and order-to-ship cycle times more dramatically than plants not using MES.

Another important aspect of process success is **cycle time**. In the overall Best Plants Benchmarking Database 3.0, the plants using MES have reduced both manufacturing and order-to-ship cycle times more dramatically in the previous three years than plants that do not use MES. (Figure 9.) The plants using MES have reduced their manufacturing cycle times by 53%, compared to 38.8% for plants not using MES. Order-to-ship cycle times have been reduced 49.6% compared to 40.4% for those not using MES.

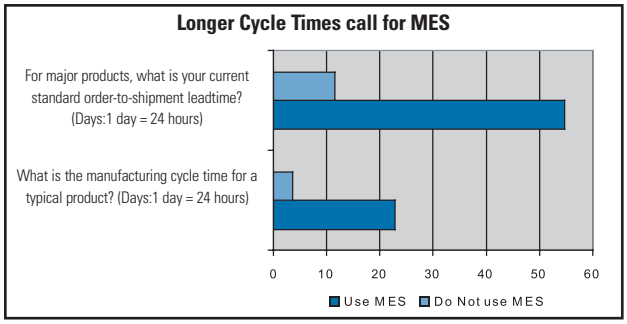

Figure 10: Plants with long cycle times tend to use MES, while those with shorter cycle times tend not to use MES. Since more can go wrong during in-plant cycle times, it makes sense that these plants would choose MES.

In aggregate, the plants using MES have significantly longer cycle times than those plants not using MES. (Figure 10.) Plants using MES have 22.9 day average manufacturing cycle times for a typical product compared to 3.6 days for plants not using MES. Standard order-to-ship cycle time for major products is 54.8 days in plants using MES versus 11.5 days for plants not using MES.

We anticipated that much of this might be attributed to the fact that every project-oriented company in the database uses MES and fewer continuous process plants do. However, our analysis shows that even among line, batch and job shop plants, those using MES have significantly longer manufacturing cycle times and order-to-ship cycle times.

Using MES for long cycle time products is logical. Plants in which the manufacturing process takes a long time have a strong incentive to invest in a system that can track, manage and facilitate operations across the plant.

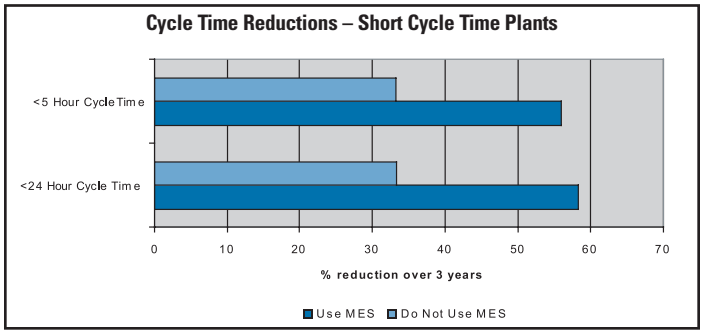

Figure 11: Plants with short cycle times that use MES have reduced their cycle times even more dramatically versus those that do not use MES compared to the Best Plants population, shown in Figure 9.

However, Best Plants with the shortest cycle times also use MES in large number. Of the plants with under 24 hours cycle time, over 50% use MES, and they have reduced their manufacturing cycle times by 75% more than similarly short cycle time plants not using MES. Narrowing this group further, 40 plants report manufacturing cycle times under five hours. Of these, 45% or 18 use MES. Within these **short cycle time groups, the cycle time reduction differential for using MES is even more dramatic** than in the overall group. The mean reduction in cycle time for this group of plants using MES was 56% compared to 33.2% for those not using MES. (Figure 11.)

Within the shortest cycle time plants, the group using MES also has significantly higher Cpk (30% higher for those with under five hours cycle time – 2.2 vs. 1.7). The under five hour cycle time plants using MES also enjoy 40% lower customer reject rate and scrap and rework rates. Warranty costs are lower, and inventory reductions were greater in all categories for those using MES.

On-time delivery percentages are nearly identical for those using MES and those not using MES. The plants not using MES had 97.7% on-time deliveries compared to 96.9% for those plants using MES. Given such long cycle times, this looks good for those that use MES.

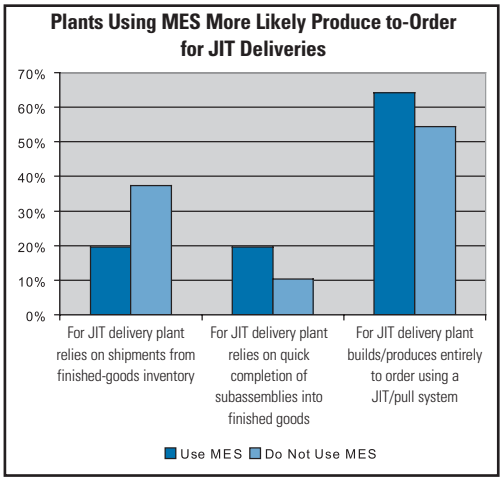

Figure 12: The traditional way to ship a customer order JIT was from finished goods stock; those using MES are more likely to complete sub-assemblies or build entirely to order with a pull system.

Agility to handle **JIT deliveries on a to-order** basis is also stronger in plants that use MES. While nearly all of the plants in the database offer JIT delivery (98%), how they accomplish it differs. (Figure 12.) Those plants not using MES are more likely to ship from finished goods stock (37.5% vs. 19.6%). The plants using MES are more likely to rely on quickly completing subassemblies (19.6% vs. 10.4%) or to produce entirely to order (64.3% vs. 54.2%). The plants using MES are better able to accomplish this in part because they have decreased lot sizes more dramatically in the previous three years (56.1% vs. 44.4%).

Another process-related factor to consider in a manufacturing plant is **maintenance**. The average machine availability as a percentage of scheduled uptime is slightly higher in plants using MES, and the proportion of maintenance work that is reactive is a mean of only 78.4% as much as those not using MES. This is true despite the plants using MES in this study having much shorter mean time between equipment failures (MTBF) – 95 hours compared to 2,707 hours for plants not using MES.

The MES' real-time data about the process and the products it is producing most likely contribute to the lower maintenance headaches. Even in the face of equipment that is far more likely to break down, these plants use less of the maintenance team's time on unexpected breakdowns. Continuous readings on product and process parameters, correlated and available for viewing across the plant, are hallmarks of MES capabilities. Without such a plantwide system, emerging maintenance issues are less likely to be identified before they become real issues.

MES Boosts Six Sigma Results

Many manufacturing plants are undertaking Six Sigma programs. To successfully identify the sources of variation and customer-perceived problems, a Six Sigma program requires reliable sources of data. MES can provide an accurate and timely data stream for Six Sigma initiatives. In the Best Plants database, 14 of the 24 companies – or 58% – with Six Sigma initiatives also use MES. Despite the small numbers, the differences within this group are striking enough to note.

Productivity comparisons are similar to the overall Best Plants group. Process and cost improvement is where the major benefits lie for using MES and Six Sigma together. (Table 3.) They have decreased lot sizes and build more to order; the result is higher inventory turns – 34.5 vs. 22.4 for those in the group not using MES.

Plants using MES along with Six Sigma saw a mean increase in volume of over 2.5 times, compared to just 13.7%, and still their customer retention rate is 99.5% vs. 98% for those using Six Sigma without MES.

Measure	Six Sigma Edge with MES
Profit Improvement	678%+ higher gains – 3 yrs.
Cost Factors	
Unit Cost reduction - 3 yrs.	68.4% greater manufacturing cost reduction; 58.6% total
Warranty as % of revenue	0.3% vs. 0.4% - 75% as much
Toxic waste reduction	81% greater – 41% vs. 22.5%
Energy Consumption reduction	57% greater energy reduction
Process Capability	
Process Capability	60% better Cpk – 2.4 vs. 1.5
Cycle time reductions	82.5% greater mfg. cycle time cuts; 54.5%+ order-to-ship
BTO for JIT orders	3X as likely pure to-order
Employee Effectiveness	
New employee training time	80% as much training needed

Table 3: Companies using MES in conjunction with their Six Sigma initiative show greater cost and process benefits.

Employee Effectiveness

MES should help the people in a plant, as well as the processes. The *Industry Week* Best Plants all have a strong level of employee involvement and self-directed work teams (86.3% of the workforce is in a self-directed or empowered work team in plants using MES, 85.8% for others). The difference with plants using MES appears to be that their labor market is more challenging.

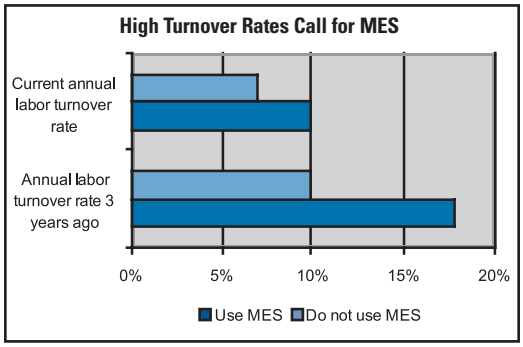

Figure 13: Plants with high employee turnover rates find that using MES can improve continuity and quality.

MES can also be beneficial in plants with labor issues. MES tracks many of the product and process issues that personnel need to understand quite deeply to manage effectively in manual systems. In many cases, MES also guides workers through each step of the production process. In this study group, 60% of the plants using MES have 500 or more personnel, compared to 33% of plants that do not use MES. And of the plants under 500 employees, 42% use MES and gain similar benefits to larger facilities.

The Best Plants that use MES are far more likely to face high **employee turnover** (Figure 13.) While both groups of plants have reduced turnover rates, those using MES have reduced turnover rates more dramatically in three years. Plants that use **temporary and seasonal** workers are also more likely to use MES – 86.2% versus 72.9% for others.

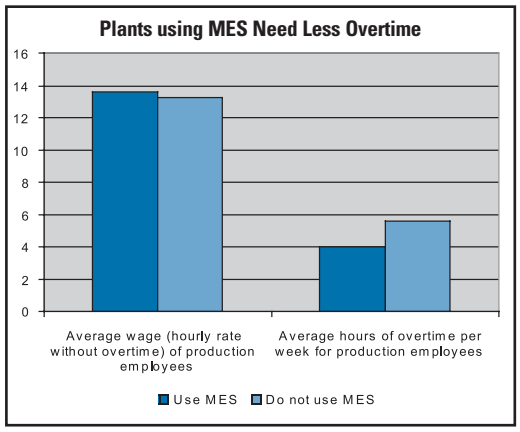

Figure 14: While pay rates are similar, plants using MES generally work less overtime than those that do not use MES. This relates to high productivity.

While all of the plants in the Best Plants Benchmark database pay similar hourly wages on average, production employees in the plants using MES work **fewer overtime hours** per week. (Figure 14.) The predictability of processes in these plants – along with the guidance employees receive directly from the MES – probably account for much of that success.

MES clearly changes the requirements for **employee training** as well. The overall training budget is nearly identical as a percentage of annual labor costs across all of these Best Plants – 2.8% for those using MES vs. 2.9% for others. (Though plants under 500 employees that use MES spend only 2.3% of their annual labor costs on training, compared to 2.9% for other small plants.) The percentage of production employees with multi-skill certifications is also nearly identical across the groups 74.8% of those in plants using MES and 74.9% in those not using MES.

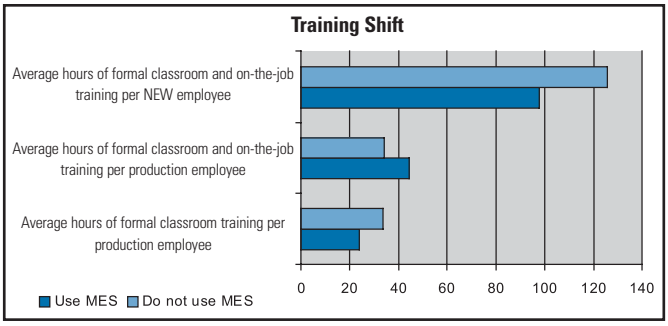

Figure 15: Plants using MES provide more on-the-job and less classroom training per employee; new employees require less total training as well.

However, the major differences include the quantity and type of training required. The number of hours an employee needs in the classroom is less in plants using MES; these plants provide more on-the-job training. (Figure 15.) New employees also need quite a bit less training in plants that use MES. Again, having the system always available to guide the operator's activities clearly makes a big difference in employee training.

A few more of the plants that have invested in MES have also established a training curriculum with a local educational institution (93% vs. 81%). This type of broad thinking and leverage of community academic resources can further a plant's training effectiveness.

Plants that use MES also take in nearly twice as many improvement suggestions per employee per year (8.2 vs. 4.4 for plants not using MES). They implement about the same number of these employee suggestions each year, 3.2 vs. 3.3. The plants using MES also measure employee satisfaction more frequently, at a mean of 5.5 times per year vs. 2.9 times per year in plants not using MES.

Profile of Best Plants that Use MES

We have highlighted many of the performance advantages enjoyed by the plants that use MES among the *Industry Week* Best Plants finalists and winners. What is interesting to note is that the plants that use MES are different in other ways too.

- **Technology Users**: Plants using MES are more likely to use every one of 21 other technologies listed in the survey, from ERP to CAD to advanced planning and scheduling to simulation. They are more likely to use computerized SPC and less likely to use manual SPC. They also have 53% higher IT budgets as a percentage of annual sales, and spend more than double on production equipment compared to the group that does not use MES.
- **Volume Gainers**: Plants using MES gained 4.5 times more volume than those not using MES over the previous three years (161% vs. 35% volume growth).
- **Product Innovators**: Plants using MES had more dollar volume of products introduced less than a year ago than others (38% vs. 32%).
- **Cellular Adopters**: Over 81% of the plants using MES have widely adopted cellular manufacturing techniques, compared to just 64.9% of others. This may be partly because continuous flow plants are less likely to use MES.
- **Lean Automators**: Despite the conventional wisdom that using a pull system with Kanban signals requires no software, more of those using MES use such systems internally than others (59% vs. 54%). Further, 70% more of the plants using MES have widespread deployment of JIT and Kanban with suppliers, and they get 2.5 times the percentage of goods in by point-of-use deliveries from suppliers, measured in dollar value.
- **Rush Artists**: Plants using MES handle double the volume of rush orders that plants not using MES do – 8.4% vs. 4.2%.

Conclusions & Considerations

Manufacturing Execution Systems can boost profitability, productivity and process performance, plus assist people in their jobs. In the *Industry Week* Best Plants finalists and winners from 1998-2002, these benefits are clearly evident.

On nearly every measure, plants using MES improve more rapidly than those that do not. This phenomenon comes not only from the system capabilities for plantwide visibility, accurate real-time data about production processes and issues, and operator instructions – it also comes from the empowerment of the production employees. A benefit that we suspect contributes, but is measured more at a corporate level, is that other systems throughout an enterprise can use this more accurate and real-time data.

If manufacturing is a core activity for your company, MES is worth the investment. The best of the Best Plants use it today. They are improving faster, and meeting greater challenges more effectively. Those who do not could be left behind quickly.

About the Author

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Julie Fraser is a recognized industry analyst, consultant and marketer, specializing in manufacturing and distribution strategies and application solutions. Fraser's reputation and expertise in supply chain, plant floor, integration, enterprise and business-to-business software solutions has kept her in demand as a leading advisor, speaker, and consultant.

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Fraser co-writes the AppsLab column in Managing Automation magazine with her Industry Directions partner Alice Greene. Previously, she had regular columns in MSI, Midrange ERP, APS, and APICS magazines. Fraser has also written pieces for other vertical industry and manufacturing software publications during her six years at Industry Directions.

Fraser has a degree with honors from Lawrence University in Wisconsin. She is a member of Phi Beta Kappa, APICS and CASA/SME, and has also served on boards for the local Massachusetts CASA/SME chapter.

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