

Advancing facility planning

Education and practice in Asia fall short of Europe and the United States

By Robin Owens



LOW OPERATING COSTS HAVE DRIVEN MUCH OF GLOBAL manufacturing to Asia. Many industrial engineering positions have moved there as well. But how competitive are the industrial engineers in the Far East? From a facilities planning perspective, IEs in Asia are behind the curve. Facility layout IEs typically aren't aware of commercial facility layout packages and, as a result, primarily depend on the AutoCAD drafting tool to do their work.

For example, one semiconductor firm in the Philippines spent \$24 million over a five-year period on factory layouts, all without using industrial engineering tools to measure and compare different layout alternatives. Layout IEs often become more draftsman than engineer. This is the normal state of facility layout in Asia.

Young IEs are expected to be aware of the latest technology. Facility layout textbooks don't do enough to communicate the existing industrial engineering soft-

ware tools on the market. Furthermore, the facility layout technologies taught in many universities are impractical algorithms that have little application in industry.

Because of this perceived lack of technology, companies spend millions of dollars every year on re-layout projects without the use of industrial engineering software.

The fact is that useful facility layout technology does exist. These tools perform Richard Muther's systematic layout planning (SLP) and systematic handling analysis (SHA) methods, and add analysis tools within AutoCAD that IEs need. Communication about these tools in Asia has not been effective or sufficient. This yields lower skilled IEs and less realization of the value of the IE profession.

Scholarly disassociation

There is a significant disconnect in Asian schools between facility layout educa-

tion and actual practice. Perhaps the most popular facility layout textbook is *Facilities Planning* by James A. Tompkins, John A. White, Yavuz A. Bozer and J.M.A. Tanchoco. In the fourth edition, released last year, 6 percent of the book (52 out of 854 pages) is dedicated to impractical algorithmic approaches. These computer algorithms include CRAFT, BLOCPLAN, LOGIC, SABLE and MULTIPLE. In the most popular facilities planning textbook, the authors state that "commercial versions for these algorithms do not exist, or must be obtained by the original author."

While these computer algorithms focus on appropriate layout aspects like relationships and material flow, they are not used in industry because of their limitations, which include unrealistic assumptions, department shapes, consideration of building aspects like utilities and columns, and qualitative factors. More importantly, they don't address the problems faced by layout IEs.

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One must ask the question, “Why is so much content and time spent on technology not in use by practicing IEs?”

Only one out of 854 pages is dedicated to commercial facility layout packages (FactoryFLOW and FlowPlanner). On the other hand, four pages deal with dynamic simulation (ProModel, AutoMOD and others). This type of simulation is a useful tool at times for facility layout studies. However, the models often take a long time to create and become very complex. Again, the Asian IE student is left without the knowledge to practice facility layout work in industry.

Most facility layout educators in Asia teach Richard Muther’s SLP. Nearly every IE in Asia recognizes the SLP methodology, though they might not be able to name it. SLP is by far the most famous facility layout technique in the world. Relationship charts and relationship diagrams apply in any environment in any industry. Color-coding the flow and nonflow relationships based on importance level and scoring layouts based on relationship weight and length provide useful layout information to IEs. Perhaps that is why SLP has stood the test of time.

But, in truth, practicing IEs don’t use SLP very much. Muther first created SLP in 1961, which was 15 years before the first personal computer was available (Apple I in 1976, IBM PC in 1981). So Muther’s methods are manual (paper, colored pencil, and ruler). One major reason why SLP isn’t used much is that it is just too time consuming.

Muther’s systematic handling analysis (SHA) also applies well in industry. Representing higher frequency material flow with thicker lines and color-coding these lines based on intensity of flow help the IE minimize material handling distances. So SHA addresses material flow, often the predominant issue for facility layout projects in industry. But

SHA was published in 1969. Again, it is a manual method not used much in industry today.

It is intuitive that SLP and SHA should advance from manual to automated versions to make these sound and valuable methods more useful to industry.

Professors in Asian universities know the importance of teaching engineering technology to students that will help them in the future. If the latest facility layout textbooks emphasize impractical computer algorithms instead of commercial facility layout packages, then how is the professor supposed to know better? As a result, industrial engineering students are taught CRAFT and similar algorithms. Students are taught tools that they will not see, or use, again. Though all of the computer algorithms for facility layout have the best intentions, they stop short of meeting the IE’s needs, and therefore are not used in industry.

The needs of the professional

When designing a facility, most companies do not struggle with placing the departments in an optimal orientation, which is the problem solved by the computer algorithms. Instead, they struggle with visualizing and measuring the relationships and then evaluating and discussing the trade-offs of layout alternatives, which contain different levels of constraint optimization. The computer algorithms address a minor problem, not the major problems for practicing IEs.

Layout IEs spend a significant amount of time tweaking designs (changing space shapes) trying to make equipment fit given the physical constraints, such as aisles, columns and utility locations. Layout IEs also face qualitative constraints from various stakeholders that become a major influence on the layout design process. For example, constraints may include placing the newest machines

near the aisles for customer tours and management politics. Flexible, interactive tools that can consider the many and varied constraints are more valuable than a limited, rigid program.

Human interaction in the layout design process is required for a number of reasons. In a business operation, most relationships (flow and nonflow) are not 100 percent accurate. Engineers have different levels of confidence in their values. These factors subject the relationships to qualitative, human interpretation. Adjustments during facility planning might make major trade-offs to satisfy a particular layout constraint.

Algorithms use fixed input requirements and then achieve an optimal, or near-optimal, solution. During a layout project such as a kaizen, new product launch or expansion, the input requirements are not fixed. Relationships between areas change over time. Space requirements and the shape of the spaces, which often are highly irregular, are not fixed. In other words, you might be able to satisfy a particular relationship/flow constraint only if the department used 10 percent less space. The algorithms do not take this into account.

IEs work on teams. A good layout needs to be “sold” to the team responsible for that layout. Visual feedback is required, and it must be as accurate as possible for quick and effective communication of layout alternatives to the team. Algorithms lack this visual feedback capability of diagramming relationships and flow lines. This visual feedback, including metrics, provides a basis for meaningful discussion about the layout. This issue is related to the lean manufacturing movement. Lean manufacturing techniques are not highly analytical. Instead, they are presentation-oriented for discussion and making decisions.

The computer algorithms may provide some value by generating the initial

layout or recommending alternate layouts. However, the bulk of time spent and value obtained in facility layout comes from the graphical presentation and measurement of the layout, including various relationship constraints, with the ensuing group discussion and layout solution development. Practicing IEs need tools to generate diagrams and metrics that aid the team in evolving to an optimal design. IEs also need tools that allow the modification of the input requirements along the way.

These requirements, which include relationships, space, shape, orientation and flow, are not fixed during the duration of the project. Computer algorithms like CRAFT may work well for quantitative evaluation or validation in ideal circumstances, but humans still need to process this information to make a decision. The computer is not doing it for them.

In Asia, it is common for new IEs to perform facility layout as their main job function. This is the case for on-the-job training university students as well. Their tools are their knowledge (university training, familiarity with the operation) and their computer (AutoCAD, MS Excel/Word). Most layout drawings are in AutoCAD, but some people use Microsoft Excel, Microsoft Paint and other non-CAD tools in an effort to save costs. But over the long term, the IE's costs become greater due to drawing inaccuracies, longer drawing times, sharing issues and lack of layering capability. IEs in this situation are at a particular disadvantage.

One might notice the lack of layout engineering tools for the IE. The company likely has millions of dollars invested in the physical facility, but the resources required to manage and improve the arrangement of those assets frequently are neglected. The fortunate IE has AutoCAD. But the basic AutoCAD tool is just a drafting tool, not an IE tool.

LESS ENERGETIC LABORATORIES

The next time you're planning to build a new lab, model its energy use before you design the facility, according to professional engineer Mike Tillou.

Energy modeling usually compares system alternatives during design or quantifies energy performance after the design process, Tillou wrote for *R&D* magazine. Unfortunately, no matter how precise those models are, the chances to decrease a building's total energy use have diminished considerably.

Tillou notes that biotechnology, nanotechnology and medical research advances will fuel economic development this century. Building operations produce 30 percent to 40 percent of all greenhouse gas emissions, and laboratories demand more energy than typical buildings. So modeling energy use beforehand can reduce CO₂ emissions, meet the guidelines of government regulations and private incentive programs, and reduce operational costs of academic, research and industrial labs.

Predesign modeling should examine building orientation and massing; building envelope, wall and roof systems; glazing, glass type, quantity of envelope that is glazed, frame types and shading; lighting and lighting controls; plug loads, process loads and all types of laboratory equipment, including refrigeration systems; HVAC systems; and fume hoods and other containment devices.

The result of this situation is that the IE becomes more of a draftsman than an engineer. You frequently hear the industrial engineering manager say to his IE, "Rodel, tomorrow I need a layout with these racks moved over here." The IE heads back to her desk and draws what the manager requested. She submits the new drawing the next day. The IE might, or might not, sit in the meeting where the new layout is presented so that she gets a better idea of any drawing changes she needs to make. To be clear, this is not industrial engineering. This is not what we envision in the university when we're learning about algorithms, from-to charts and relationship diagrams. But what choice does the industrial engineer have when he or she isn't provided any usable technology to perform analysis and evaluation?

If the IE did have engineering tools, then you might hear her say, "Sir, I moved the racks to the new location you dictated. I quickly did some studies, and

the new layout actually caused an increase in material flow distance and cost. I moved the racks to a different location and reduced these layout metrics by 12 percent, saving \$1,000 per month. Here are both layouts for you to choose. I've included some graphics and metrics for each alternate layout in order to support your management presentation."

That would be industrial engineering.

Lean manufacturing teaches us that before we change a process we must measure it to ensure that the change is an improvement. Practicing IEs who make layout changes without measurements unwillingly violate this mandate.

The real world in the West

The genesis of modern commercial facility layout packages came in the 1980s. In 1982 AutoCAD became available as a drafting tool for the PC. In the late 1980s when Dave Sly was an industrial engineering master's candidate at Iowa State University, he automated Muther's SLP

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method inside of AutoCAD. Later, Sly created technology to automate SHA and improve upon it. This provided the ability to combine from-to and material handling cost data with the drawn-to-scale AutoCAD layout, letting IEs measure actual material handling distances, times and costs for each layout alternative. Analysis capabilities now enable sophisticated material studies to help minimize and eliminate material flow. From the high level relationship analysis to detailed workstation design, all of these IE functions could be performed using the actual facility layout drawing. Sly has developed the major commercial facility layout packages on the market today (Flow Planner from Proplanner and FactoryFLOW from Siemens PLM). Most people in the United States and Europe use such products for facility layout work.

By using automated SLP inside of AutoCAD, IEs can perform relationship studies better and faster than when using manual methods. Relationship charts are created automatically and can be printed and shared with members of the layout team. Relationship diagrams are generated automatically, and relationship lines can be viewed by relationship type or proximity, as shown in Figure 1.

Weighted factor scores are calculated automatically for all layout alternatives, saving large amounts of time spent measuring the lengths of the relationship lines. The IE can improve the layout visually or use information in provided reports. To measure and evaluate changes to the layout, the IE simply moves any number of departments (MOVE or STRETCH command in AutoCAD) and automatically recalculates all relationships to see if the changes improved the layout score.

Because most layout problems in industry are flow-based, Muther's SHA method offers significant value. IEs know lean manufacturing very well. Many have seen the spaghetti charts that are produced during kaizen events; they don't provide accurate measurements or the ability to study mass amounts of data, such as all parts for the facility. Measureable, interactive spaghetti charts that analyze large amounts of data and facilitate SHA techniques are what IEs need.

With modern facility layout packages, IEs take from-to chart data (product/part routings), combine them with the drawn-to-scale layout drawing, and automatically produce material flow diagrams and quantitative metrics for each layout

option, as shown in **Figure 2**. Material handling time, distance and cost metrics are calculated automatically for each layout option, which gives a quantitative basis to compare alternatives. If the IE wants to evaluate a layout change, he or she simply moves the from-to locations in the drawing and recalculates the material flow. The resulting metrics reveal whether the change was an improvement. Automatic reports can be analyzed as well to determine opportunities for improvement.

The visualization of material flows within a facility allows the IE and the layout team to visualize and improve the layout quickly. Backtracking is clearly visible. From Muther's SHA, thicker flow lines represent higher frequency travel between two points. Therefore, thick flow lines with long distances reveal opportunities to improve the facility layout. Furthermore, IEs can color-code the flow lines and analyze by product, part, container type, material handling and other methods.

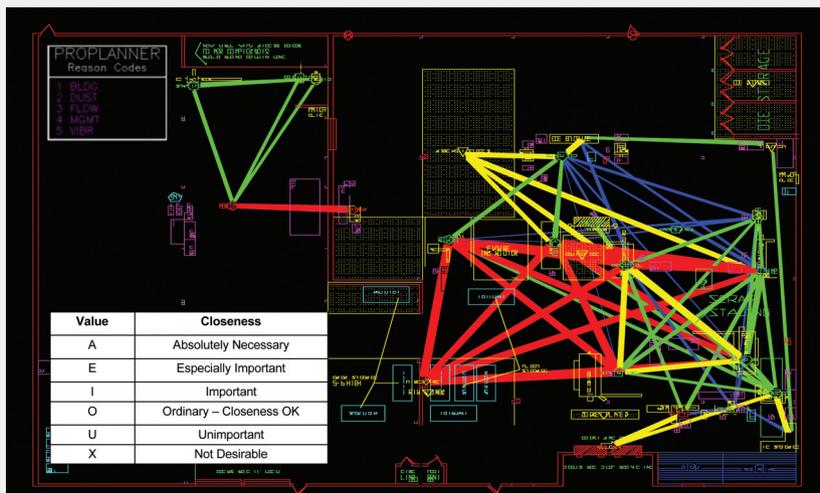
Modern facility layout packages provide analysis tools beyond Muther's SHA. Because commercial software uses the facility layout drawing, IEs can draw a network of aisles (one- or two-way segments). Then the from-to locations are connected automatically to the aisle network. Then the IE can send the material flow down the actual path network (rectilinear flow lines) to obtain accurate distance, cost and time metrics for the layout.

Following this, the IE can perform congestion analysis to determine which aisle segments are used heavily. The aisle segments that aren't used much signal a waste of space. High congestion aisle segments show areas of potential safety, productivity and cleanliness concerns, as shown in Figure 3.

Sophisticated material handling data studies can be performed providing

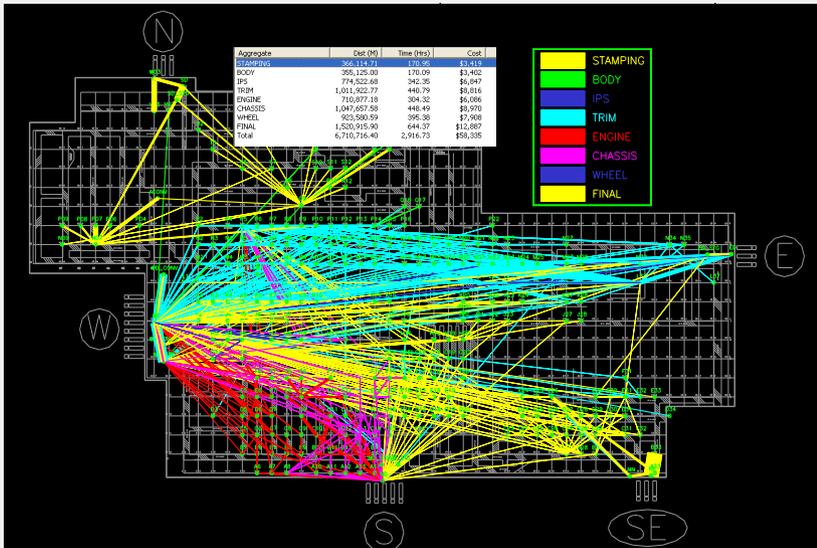
VISUALIZING RELATIONSHIPS

Figure 1. Graphical representation of vector images from an SLP project.



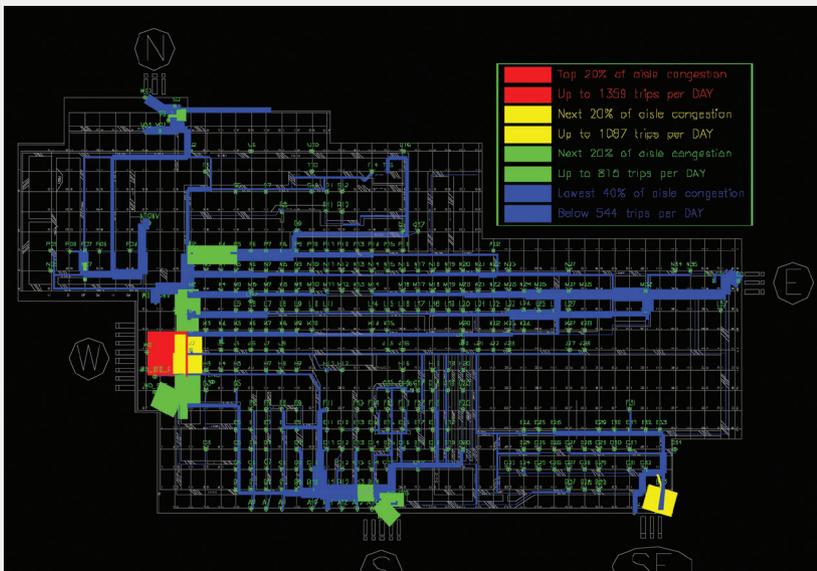
A COLORFUL FLOW

Figure 2. Graphical representation of the material flow inside an automotive assembly plant. The color codes match up to the department of use.



DISLODGING CONGESTION

Figure 3. Congestion diagram produced by sending the material flow down the actual path network at an automotive parts factory. Note the color-coded metrics chart that points out problem areas.



accurate data to support efforts to minimize and eliminate material moves, such as 3PL outsourcing, moving/eliminating storage locations, implementing point-of-use-storage and automating moves. Loading dock-storage studies can be done to determine the best way to receive and store parts, minimizing total material handling distance. Dock and material

handling device utilizations can determine resource requirements.

During material flow studies, we learn that pickup and set-down times consume a large percentage of material handling time. This is a waste of indirect labor time and resources. Having tools that can measure, help analyze and reduce this large source of non-value-added time

provides significant value to the IE.

Tuggers, or tow-trains, have been proven to reduce material handling distances within facilities. These material handling devices pick up and deliver materials on pre-determined routes. Defining and visualizing optimal tugger routes is a complex problem for IEs. Commercial facility layout packages offer tools to define and improve complex tugger routes, further reducing material handling distances for the facility.

To the future

The communication to Asian universities and IEs practicing in that part of the world about commercial facility layout packages has not been effective. The result is a lower skill level among facility layout IEs in Asia. Facility layout textbook authors and college instructors should include more on modern facility layout packages and other technologies instead of outdated algorithms, as IEs need the most up-to-date tools available. By using practical facility layout technology, IEs in Asia can begin to engineer layouts instead of just drawing them. This way, IEs can contribute more to industry and, at the same time, improve the reputation of our profession. ☺

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