

Make Work Cells Work for You

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Cellular layout and organization create compact, highly focused work environments that release a host of benefits, quality being among the foremost. Briefly, a work cell is a grouping of manual or machine processes that can produce a complete item or family of items. Cellular work stations are close enough together to squeeze out nearly all buffer inventories. No stockrooms, with potential percentages defective, intervene. Since products keep moving with little rest from process to process, misfits and nonconformities show up quickly while the trail is fresh. Identifying and rectifying root causes is that much easier.

The alternative to cells, dispersion of productive processes among geographically separated shops or departments, once was standard practice. That mode of operations creates a mishmash of flow paths, for example, from any of five presses in the press shop to any of five welders in welding. That simple case yields 25 possible routings, each loaded with its own set of potential quality problems. Those problems and their root causes hide among the large between-shop inventories and the sheer numbers of flow pathways. Moreover, as various shop-to-shop delays expansively stretch out total flow times, true causes of variations and nonconformities are contaminated by the large numbers of variables that stack up with the passage of time.

Quality-related benefits of cellular processing are summarized in Exhibit 1. Points 1 and 2 concern variation and capability. Cells improve product uniformity because minimal delays expose nonconformities before they can do much damage. Cells lower throughput time variation by keeping work moving with minimal queues, and therefore minimal queue-time delays. That puts clamps on high-side variation. A cell reduces process and method variation, because one process delay or failure quickly halts others; that plays up the need for well characterized processes and well defined methods with operators well trained and certified. By the same token, low tolerance in the cellular mode for delays and failures punctuate the need to upgrade process capability and reliability and to keep processes in tip-top shape, for example, employing total preventive maintenance.

Root cause containment is third and fourth in Exhibit 1. Early identification of root causes—the fresh trail benefit—has been explained. Next comes attack and rectification of root causes. Cells tend to enhance that effort for two reasons. One is the high need for eliminating ripple-effect problems that accumulate with processing delays; the other is the tendency of cells to pull together multi-functional minds. In labor-intensive cells—for example, assembly-test-pack—best practice is to cross-train everyone and also to move engineers, technicians, or other specialists close to the cells they support. With operatives cross-trained and job-rotated, and with expertise close at hand, root causes get suffocating attention.

Last in the exhibit is documentation. Moving productive processes out of shops in favor of cells cuts out assorted documentation for scheduling, dispatching, labor and scrap reporting, pick lists, move tickets, costing, and lot inspections—and the many potential errors that go with such administrative processing.

In short, by disallowing a multitude of interacting variables, shifting to cells is a powerful tool of quality assurance.

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| Exhibit 1. Quality Dividends of Cells |
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| <i>Quality Benefit</i> | <i>Explanation – With cells, . . .</i> |
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| 1. Reduce variation: | |
| a. Product variation | Minimal inter-process waiting exposes nonconformities that can be rectified before they accumulate. |
| b. Time variation | Limited inventory accumulations put upper limits on process times thereby reducing throughput time variation. |
| c. Process/method variation | Closely linked processes leave little latitude for time variation, which presses for well defined processes and methods, and operator certification. |
| 2. Process capability | Intolerance for process failures and downtime presses for high levels of process maintenance with upgraded capability and reliability. |
| 3. Identify root causes | Minimal-delay processing raises chances of catching nonconformities at the next process while the audit trail is fresh and root cause possibilities few. |
| 4. Attack/rectify root causes | Intolerance for process failures encourages multi-functional experienced and expert people to be at the ready for fact-based problem-solving. |
| 5. Documentation validity | Intolerance for failures presses for highly relevant and accurate process documentation; much reduced flow distances, throughput times, and organizational entities, along with elimination of stock rooms and overall process simplicity, greatly reduces administrative documentation and attendant processing mistakes. |

Firestone and the Ford Explorer Revisited

A case in point involves a quality issue that became big news in 2000: the rollover deaths, tire recalls, lawsuits, and recriminations involving Ford Explorers equipped with Firestone tires. In view of an experience of mine with Firestone manufacturing years earlier, I could not help but think that cellular manufacturing might, possibly, have saved the day. It was 1984 at a Firestone radial tire plant in Albany, Georgia. The following, adapted from a previous publication,[\[1\]](#) tells the tale:

I had been invited to conduct a one-day seminar for 56 managers on a Saturday in June. It was a typical batch-and-queue factory, in which quality problems are mostly invisible to the work force.

On arrival mid-day on Friday, I was given a thorough tour, which provided ammunition for devising a cellular plan for most of the tire-making processes. (Tire-making is discrete production, which is fed by batch production of the rubber itself—done in earlier production stages in the same plant.) I found that the plant built tires in four steps, each a “department” [or shop]: first-stage, third-stage, press-cure, and final finish. (A second stage had been eliminated when the plant converted from bias-ply to radial tires.) About twenty first-stage machines produced carcasses that went into racks holding, typically, 12,000 units. From there, 40 third-stage machines converted carcasses to “green” tires, which filled racks awaiting next processing in 200 press-cure machines. Those racks held 10,000 to 12,000 green tires.

For someone like myself—predisposed to see manufacturing through JIT/TQC eyes—12 thousand carcasses and 10 to 12 thousand green tires were a fantastic opportunity for improvement. My Saturday presentation included sketches on acetate of conversion to multiple cells. For good balance each would have two first-stage machines feeding one second-stage machine, feeding four press-cure

machines, feeding one final-finish station. Plant manager Dick Clarke and his staff were enthused and bent on implementing the ideas. (Later, with Clarke's help by mail and phone, the plan was refined and became part of a case study published in [a] casebook on implementation of JIT and TQC.[2] The instructor's manual for the casebook includes a sketch of the cells, with estimates of benefits.) Did it actually get implemented? It did not. Contrary to what Clarke wanted to do, corporate pumped in some \$20 million for automation, then shuttered the plant a year after I had visited, idling around two thousand people. (Finally, this new century is bringing forth the cellular mode of building tires. Most tire-makers are experimenting with small plant designs made up of compact cells, plus new process-linking equipment that largely avoids fork-trucking in and out of storage racks.[3])

Whether the cellular plan would have saved the plant from extinction is not the reason for this discussion. Rather it is this: Work cells give operators, supervisors, technicians, and engineers whole-process visibility and reveal quality causes while trails are still fresh. By rejecting the cellular formula, this and many other plants in the industry seem to have set themselves up for the kind of debacle that Bridgestone/Firestone experienced with its radial tires fifteen years later.

The lesson here is clear enough. It applies not only to manufacturing but, as well, to any sort of service. Department to department flows to approve loan applications, perform order entry, or process invoices have the same characteristics.

Cells at Microsoft and Hallmark Cards

A Microsoft example, circa 1991, comes to mind. At that time Microsoft had been buying around 2,000 personal computers a month; its many software products under development had to be tested on every brand of PC. Despite that volume, the company, headquartered in Redmond, Washington, had not been taking quantity discounts. The problem: it simply took too long for accounts payable to receive and process the paperwork. The processing steps involved buyers in one building, receiving in another miles away, and accounts payable in still another, remote from receiving. Included among receiving's responsibilities were several steps, ending with delivery and installation of the PC for the software group that ordered it. The solution, worked out in a break-out session at an off-site seminar at Snoqualmie Falls in the Cascade foothills, was a cell dedicated to PC acquisition and processing. A PC buyer and an accounts payable person were simply moved to the receiving building, where they became the PC acquisition cell team. The quantity-discount issue may have been sufficient reason to go cellular. The trump card was the likelihood that a co-located cell team would be face-to-face with root causes of processing errors—the quality dividend, which was a main topic of the Snoqualmie seminar.[4]

In the 1980s at Hallmark Cards, processing errors were acute, and the main cause, as at Microsoft, was geography. Producing a new greeting card was taking two years as designs bounced from building to building at Hallmark's Kansas City home complex. A card's many-digit stock number had to be entered thirteen times on sixteen documents. Getting a digit entered wrong, a high probability, could result in a store receiving Valentine's Day cards for Mother's Day.[5] In the early 1990s the company had been enjoying good results with cellular manufacturing, especially at its Topeka, Kansas, production facility. Why not in card design?

Key members of the planning team included Gray McMonigle, group VP of operations; J.D. Goodwin, VP of manufacturing; Wayne Herran, VP of graphic arts; Dennis Hobbs, VP of order distribution; and Soma Coulibaly, director of industrial engineering. They selected Hallmark's popular Shoebox line of cards as the first project. Instead of housing artists in one building, verse

writers in another, and production in a third, the whole Shoebox team moved into a single building. The artists and writers shared a single floor, with production below. Results are summarized in Exhibit 2: Stock number entries fell from thirteen to one and documents from sixteen to five, wiping out most of the chances for miscoding a stock number. Shoebox's time-to-market fell to about three months. Three departments brought together in one building yields an overly large cell, but it's a move in that quick-response, root-cause revealing direction.

| Exhibit 2. Card Design, From Dispersed to Clustered Operations | | |
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| | <i>Dispersed</i> | <i>Clustered</i> |
| Number of documents requiring stock number entry | 16 | 5 |
| Number of stock number entries | 13 | 1 |
| Time-to-market | 2 years | 3 months |

Bad Medicine

Hidden root causes and their much-delayed consequences are bad business when they involve PC acquisition or greeting cards. They can be bad medicine and kill people when they involve production of medical devices. Cellular assembly of medical products creates clear responsibility chains and clean, simple audit trails. Typically, however, medical-device production goes from gang to gang, resulting in a confusion of process flowpaths.

Consider, for example, production of IV bags, observed at Baxter International's North Cove plant near Asheville, North Carolina. The process starts with an extruder that forms the bags. Extruded bags drop onto a moving wide-belt conveyor where one gang—assemblers positioned on either side of the belt—attaches components such as valves and plugs, and another gang down the line installs more components including tubing. Other gangs further along perform testing, then packaging. If, say, at test, a bag is found to have a mis-installed valve, attempts to trace back to the assembler doing it wrong would run into finger-pointing among the assembly gang. The problem begs for breaking up the gangs and reorganizing them into cell teams, each with the same process steps. In that mode, the extruder deals out bags to each cell team, and from then on processing is hand-to-hand within each cell: first cell member installs plugs, next one valves, and so on, creating a one-to-one responsibility chain and audit trail.

Exhibit 3 shows, in the top panel, the conventional gang-to-gang way of producing IV bags. The lower panel shows the cellular alternative. In each of the three cells, it's person-to-person processing—no need for a conveyor belt. Ideally, each of the cells would have its own small extruder. But cost rules the day: the single, large extruder is already owned and has plenty of capacity, so it feeds all three of the assemble-test-package cells. Usually, a cell is U-shaped, serpentine, or—as shown here—L-shaped. Those configurations, unlike linear flow lines, put cell team members at close quarters, the better to communicate, learn each others jobs, trade jobs, and quickly react as a team to any quality issue or process problem.[\[6\]](#)

Exhibit 3.

Medical device manufacturers must adhere to strict regulatory requirements, including extensive documentation to permit traceback when there is a problem. The effectiveness of all the record keeping is badly compromised in gang-to-gang processing, since root causes are so easily

hidden among the many person-to-person flows. It is a travesty that the regulations fail to require the clarity of traceback that comes with the cellular mode.

The point applies broadly—not just for relatively simple cases of labor-intensive assembly through packaging. The majority of medical device, pharmaceutical, and food products involves department to department flow patterns in which multiple productive units in a feeder department can go to any of multiple units in the next: for example, any of several mixers to any of several dehydrators to any of several compounders, and so on. While breaking up the departments and moving the different kinds of equipment into several physical cells can be technologically non-feasible or prohibitively expensive, all is not lost. Virtual cells to the rescue.

Virtual Cells

Returning to the Firestone tire plant, movement of equipment to form cells would not have been all that expensive—probably a small fraction of the \$20 million worth of automation that went down the drain. The tire-making machines were relatively small and movable. In other cases, machines are monumental, and moving them to form cells is prohibitively expensive—physical cells, that is. An alternative, *virtual cells*, may be feasible, and if so, can unleash at least some of the benefits of physical cells.

Take, for example, an integrated steel mill. One building houses the melt shop (or department), consisting of a number of melt furnaces. The melt goes next to a nearby building for casting on any of several continuous casting lines. Then to another building for down-sizing on any of several rolling mills. All the equipment is massive; it stays put. The process flow, however, need not go from any of the melt furnaces to any of the continuous casters to any of the rolling mills. The virtual-cell concept designates single, parallel flow paths, with no crossovers (alternate flows) allowable except in special cases.

Exhibit 4 demonstrates the conversion to virtual cells assuming four of each type of equipment in each of the three buildings. The top panel shows the profusion of shop-to-shop flow paths. They add up to 192—count 'em—so many that traceback is virtually impossible. In that mode, there is kinship among the operators in each building, but no kinship or teamwork horizontally along the flow paths.

The lower panel specifies straight flows, no alternate paths. Virtual cell teams form along each of the four flowpaths. The *A* Team includes the operator of melt furnace *A*, the operator of continuous caster *A*, and the operator of rolling mill *A*. Their joint responsibility is for continuous improvement across the total *A*-flowpath. And so it is for the *B*, *C*, and *D* teams. Though their machines are geographically separated, the teammates meet together frequently to attack variation, nonconformities, wastes, and delays. They define problems, collect and analyze data, call in expert assistance as needed, isolate causes, and solve problems. For each cell team, any dip in performance stands out, and tracing it to its source involves only that team's facilities and methods.

Exhibit 4

This example of virtual cells in a steel mill emerged during an afternoon seminar that I was conducting at the Cometas integrated steel mill, Campana, Argentina, up river from Buenos Aires. I had been explaining the virtual-cell concept, remarking that probably "it would not apply in your company." Engineers in the audience corrected me, pointing out what I should have noted in my tour through the facilities that morning: multiple melt furnaces in one building, multiple continuous casters in the next one, and multiple rolling mills in a third. So why couldn't they designate equipment for one-to-one flows? Touché.

If a day's production of steel pipe fails porosity tests, what's the cause. In shop-to-shop production, no amount of statistical analysis of data is likely to find out; there simply are too many variables. The number of variables plunges when pipe making is channelled through four virtual cells. Instead of searching galaxies for causes, it is just a few planets.

Cashing the Dividend

In the late 1970s and early 1980s, planeloads of Western manufacturing people went to Japan on study missions. Cellular processing, a foreign idea at the time, was prominent among their observations. They saw, and often did not fully understand. The simplicity and fast throughput was apparent. The tendency to make use of smaller, simpler equipment, so that each cell could have its own, was harder to understand.

Quality, per se, was far easier to appreciate, and the quality movement, led by W. Edwards Deming, Joseph Juran, Philip Crosby, and others began to soar beginning in the early 1980s. Just-in-time, the centerpiece of the Toyota production system, with high emphasis on conversion to cells, took flight as well. Since JIT was famed principally for slashing throughput times and inventories, the quality dividend of cellular manufacturing was tended to be under-appreciated. That dividend makes all the difference. It is waiting to be cashed in wherever cellular operations are feasible.

Richard J. Schonberger is author of several books, including *World Class Manufacturing: The Lessons of Simplicity Applied* (1986), *Building a Chain of Customers*: (1990), and *Let's Fix It! How the World's Leading Manufacturers Were Seduced by Prosperity and Lost Their Way* (2001). A member of ASQ for over 20 years, Dr. Schonberger is president of Schonberger & Associates, Inc., Bellevue, Washington, and can be contacted at sainc17@qwest.net

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[2] Richard J. Schonberger, *World Class Manufacturing Casebook: Implementing JIT and TQC*: Free Press/Simon & Schuster, 1987, pp. 165-172.

[3] Timothy Aepfel, "Mounting Pressure: Under Glare of Recall, Tire Makers Are Giving New Technology a Spin," *Wall Street Journal*, March 23, 2001, pp. A1 and A8.

[4] Richard J. Schonberger, *World Class Manufacturing: The Next Decade*: Free Press/Simon & Schuster, 1996, pp.23, 28.

[5] Ibid, pp. 33-34.

[6] Cellular layout of IV-bag assembly was discussed but not implemented at North Cove. However, the plant did adopt a recommendation for a considerably larger project in which three product-focused cells were created involving large-scale equipment including sterilizers and packaging machines

