Award

Winner

NCR Cashes In on Design for Assembly

For six years now, *Assembly Engineering* has conducted an annual search for the nation's outstanding example of applied assembly technology and thinking. The PAT Award (Productivity through Assembly Technology) is why we do it, and this year's recipient is William R. Sprague, senior advanced manufacturing engineer, NCR Corp., Cambridge, OH.

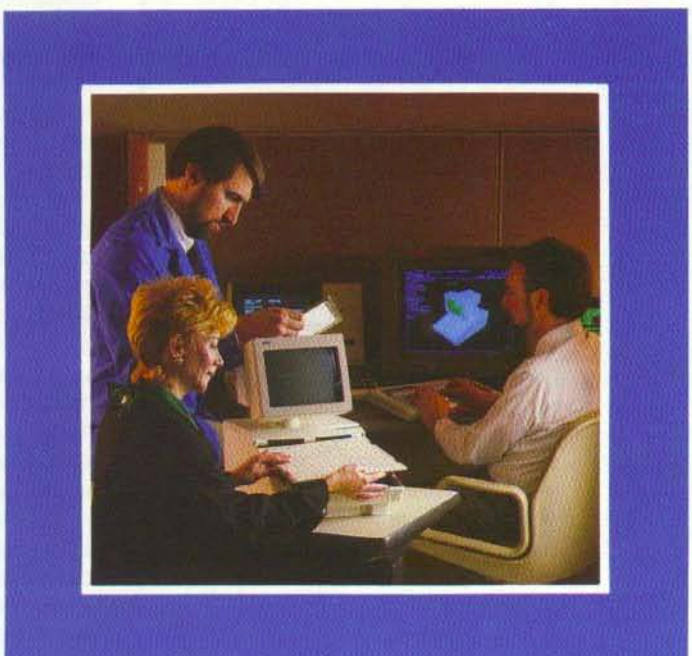
He was the prime mover in rigorously applying Design-for-Assembly (DFA) methodology during development of a new point-of-sale terminal called the 2760. The product and its associated manufacturing process realized the following benefits vis-a-vis the previous generation terminal:

- 65% fewer suppliers
- 75% less assembly time, with 100% fewer assembly tools
- 85% fewer parts (100% fewer screws)

The new terminal, in fact, has 55% fewer parts than the previous one had screws. To highlight the impact, it was estimated that the cost of just one screw (material, labor, and burden) over the 2760's life was $12,500. Further, total lifetime manufacturing labor cost for the terminal was estimated at $1.1 million less than the prior product, a 44 percent improvement.

Obviously, these numbers are significant; however, even greater savings are expected in areas such as inventory, field service, plant-floor space, production-support costs, and capital equipment. Tooling development, for example, went straight from the design stage to hard (steel) tools rather than the typical intermediate step of using soft (aluminum) tools. Sprague points out that initial tooling only needed minor modification.

Also, the testing and introduction period for the 2760 was remarkably trouble-free. It cleared difficult tests such as EMI emissions on the first pass.



Bill Sprague (left), this year's PAT Award recipient, reviews first-off plastic components against a solids model with automation design engineer, John Wallach, and Sandra Smith, a representative of the CAD/CAE system vendor, SDRC.

JOHN R. COLEMAN
Editor

"NCR Cambridge has a major JIT program in progress," Sprague remarks. "The 2760 terminal was designed with that in mind."

Team Work Works

NCR uses multiplant task forces and corporate-assisted pilot projects to explore DFA tools and strategies. The 2760 began as such a project in January, 1987. Mechanical design was completed October, 1987, with commercial roll out expected this month. Sprague and John Wallach (from the Design Automation Group) were the project's champions. Their focus was on the mechanical portion of the design.

"U.S. Industry finally is recognizing DFA as a strategy for leadership," comments Sprague. "But, for it to achieve significant results, you must first overcome two obstacles: Implementing a major cultural change in the organization (and gaining acceptance of it); and blending computer-based tools and design process changes in the right mix to optimize development effort."

All astute organizations realize that success comes from the skills and efforts of its personnel. The difficulty is getting the right people, in the right structure, with the right tools, to maximize results.

"We formed a multidiscipline team to simultaneously design the product and manufacturing process for the 2760 terminal," reflects Sprague. "John and I drafted the project plan, then sold it to the director of manufacturing and the director of engineering, making sure all expectations and schedules were in agreement.

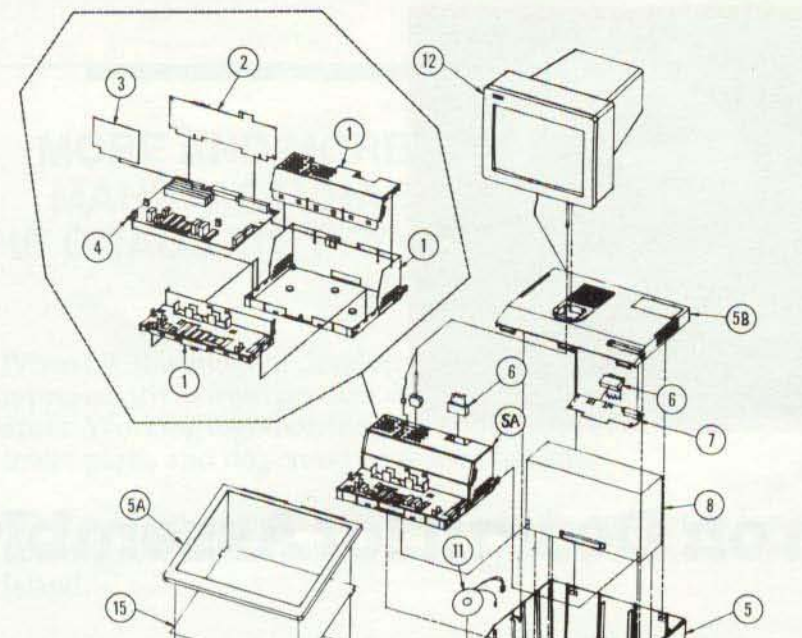
"We then established a high-level goal of having quality product and manufacturing process designs in place prior to prototype development and production. Our primary measurements were to meet schedule and cost goals, and minimize assembly time and part count. All other benefits and measurements were derived from these high-level goals and basic measurements."

Team members were invited from product design, customer service, manufacturing engineering, test engineering, product management, industrial design, quality engineering, purchasing, vendor quality, safety engineering, EMI engineering, program management, and human factors. Critical vendors also were brought in as part of a co-destiny supplier relationship. The plastics molder and tool-and-die builder, for instance, were selected early to exploit their knowledge of molding and toolmaking. Suppliers also had to comply with NCR's JIT and SPC programs, and have ability to accept CAD file transfers, which helped reduce tooling quotation and delivery time.

Weekly team meetings were held, with interaction among key members more frequent. Also, presentations were given on how DFA works, and examples of successful applications were distributed.

Each member was expected to develop objectives relative to his area of expertise. Prior to the start of hard design, these objectives were shared with the group to foster an understanding of what manufacturability, testability, and serviceability really meant.

The team pursued design solutions that met or exceeded all objectives,



Assembly Details

The line drawing is an exploded view of the 2760 terminal. The lone subassembly is the snap together electronics box (1), which contains three snap and plug-in pc boards (2, 3, 4). The plastic terminal cabinet base (5), like the sheetmetal electronics box, is delivered assembled to the production floor by the vendor as part of NCR Cambridge's JIT program.

The bezel (5A) and top (5B) are removed from the cabinet base to start the assembly process. The lone separate harness (6) is plugged to a pc board (7), which then snaps into the cabinet top (5B).

The power supply (8) is purchased from NCR's Orlando, FL division. It handles either 110V or 220V power, with internal sensing that eliminates the need for switching or multiple power-supply assemblies. It also contains the 2760's cooling fan. The power supply is simply set into the cabinet base and the cabinet top is snapped back on to hold it.

The terminal is turned on its side for plugging the ac power cord (9) into the cabinet base and power supply, and snapping it into a strain-relief tab in the base. The terminal then is turned on its back to apply a single label containing serial number, license, and product information.

The terminal is set upright for sliding in the electronic box assembly (SA), which mates to the power supply for grounding and current, and snaps into the cabinet base to hold it in place. The speaker (11) slides into a holder in the cabinet base for a snap fit and then is plugged into the electronics box. The harness (6) from the pc board (7) in the cabinet top also is plugged into the electronics box.

The CRT (12) cables are fed through a hole in the cabinet top, and then the CRT pivot slides through the hole and is twisted a quarter turn to snap the CRT into place. The CRT connectors then are plugged into the electronics box. Both the CRT and speaker are common to other NCR terminal products.

The keyboard (13) is set into the cabinet front, sliding up to mate to the pc board in the cabinet top and snapping it into place. A keyboard overlay (14) and Mylar cover (15) then slip into tabs in the keyboard (13), and the cabinet bezel snaps back into place to hold them.

The 2760 assembly requires only 15 vendor-sourced parts, and no separate fasteners are used. The terminal cabinet has a number of snap-in escutcheons that can be removed to easily customize it.

adamantly resisting compromises. A parallel approach permitted simultaneously developing the product design and manufacturing process, which allowed trade-offs between the two as changes were made. This was the key to the pilot project's success.

"Prevention versus Contingency" planning helped isolate problems and point to solutions while the design was still in the CAD system rather than at the testing/prototype stage. Team members openly shared progress and problem reports, eventually developing a consensus before releasing the design. This created multiorganizational design ownership, with all members responsible for meeting the group's objectives. For example, the manufacturing engineer shared with the product engineer (and the rest of the team) in accepting the 2760's manufacturability. They worked up front to define what was expected from the design rather than waiting for a review.

"An important task during the project was upgrading the skills of the team members," recalls Sprague. "At the start of the project, courses were held on using SDRC's GEOMOD solids modeler and the Boothroyd Dewhurst DFA Toolkit software. John and I provided follow-up training and assistance."

CAE: Computer-Aided Everything

The mechanical portion of the design was done from concept to completion on GEOMOD, remaining as a solids model until details were approved by the team. Then the electronic information was transferred to vendors for tool manufacturing.

"Solids modeling was an excellent means for designers and team members to visualize concepts," says Sprague. "The complete assembly, or any element of it, could be viewed just as it would physically appear. This stimulated input from group members because they could see and understand how the 2760 was defined early in the process. In addition, they spent more time working on design solutions rather than just figuring out what parts fit where.

"Subsequently, the designers were forced into greater discipline as details had to be defined at each stage. By using program files, they could make changes without recreating the entire part. The software performed interference checks among the parts to assure the team that form and fit problems were being addressed. The electronically captured design data also automatically yielded volume and mass information to assist in structural analysis and for quotation of molded and cast parts."

NCR's 2760 point-of-sale terminal. Part count and assembly time were tracked during the development effort; using DFA techniques permitted reducing them 66% and 23% (respectively) from original conceptual estimates.

VAX-based CAD stations worked well for design, but were slow when the team wanted to review the completed parts. High-performance Hewlett-Packard 350SRX workstations were trial leased to expedite the on-screen review sessions. Component and assembly details then could be real-time analyzed by group members. This was especially important to the manufacturing engineer because he could quickly interpret product changes and make appropriate manufacturing process modifications.

"CAE analysis was used to leverage overall quality improvements," Sprague continues. "For example, the terminal's cabinet consists of complex injection-molded plastic parts that were analyzed with Moldflow and Polycool II to verify tool design. There also is potential for structural and thermal analysis, which hold promise for further reducing tool changes and improving component quality."

The completed part designs were electronically released to the tooling vendor; no paper drawings were issued. Tool-path information was added and then directly fed to CNC machine tools.

Part geometry was created only once to reduce engineering effort, separate documentation from design, and reduce interpretation error. Documentation for inspection and assembly drawings was generated on an as needed basis. A critical element of this paperless CIM environment involved securing the design's electronic file by developing an archiving system.

Tool of the Trade

Throughout the 2760's development Boothroyd Dewhurst's DFA Toolkit software provided an early analysis of assembly time and sequence, not just a finished-design autopsy. By using a Pareto analysis of the assembly time data, opportunities for improvements were identified to challenge the team. Parts and times were categorized by functional and nonfunctional purposes to highlight the cost of decisions and problem areas. According to Sprague, this enhanced design-solution synergism among group members. The data also was used to keep top management up to date on the team's progress, and was essential to maintaining support of the project.

"The DFA Toolkit focused on key guidelines for improvement," Sprague notes. "We concentrated on reducing assembly time and part count, which significantly impacted the entire organization and our suppliers. In particular, fasteners were eliminated through snap-fit assembly and cables/harnesses were reduced through direct interfacing, which also improved reliability and quality. The remaining parts were designed for Z-axis assembly to minimize handling and insertion time."

Last June, Sprague illustrated the 2760's ease of assembly by manually putting it together in less than two minutes while blindfolded at the Third International Conference on Product Design For Manufacture & Assembly (Newport, RI). Of course, customer acceptance will be the ultimate judge of the project's success, and initial commercial interest for the 2760 terminal is strong. Moreover, several companies that are pursuing their own DFA projects want to replace the formerly used IBM Proprinter with a 2760 for internal demonstrations.

"We have initiated several other projects with greater potential impact, including pc board DFA," boasts Sprague. "Assembly time and part-count reductions are forecast in the 90% range. Design for Assembly is truly a cornerstone of manufacturing excellence."

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