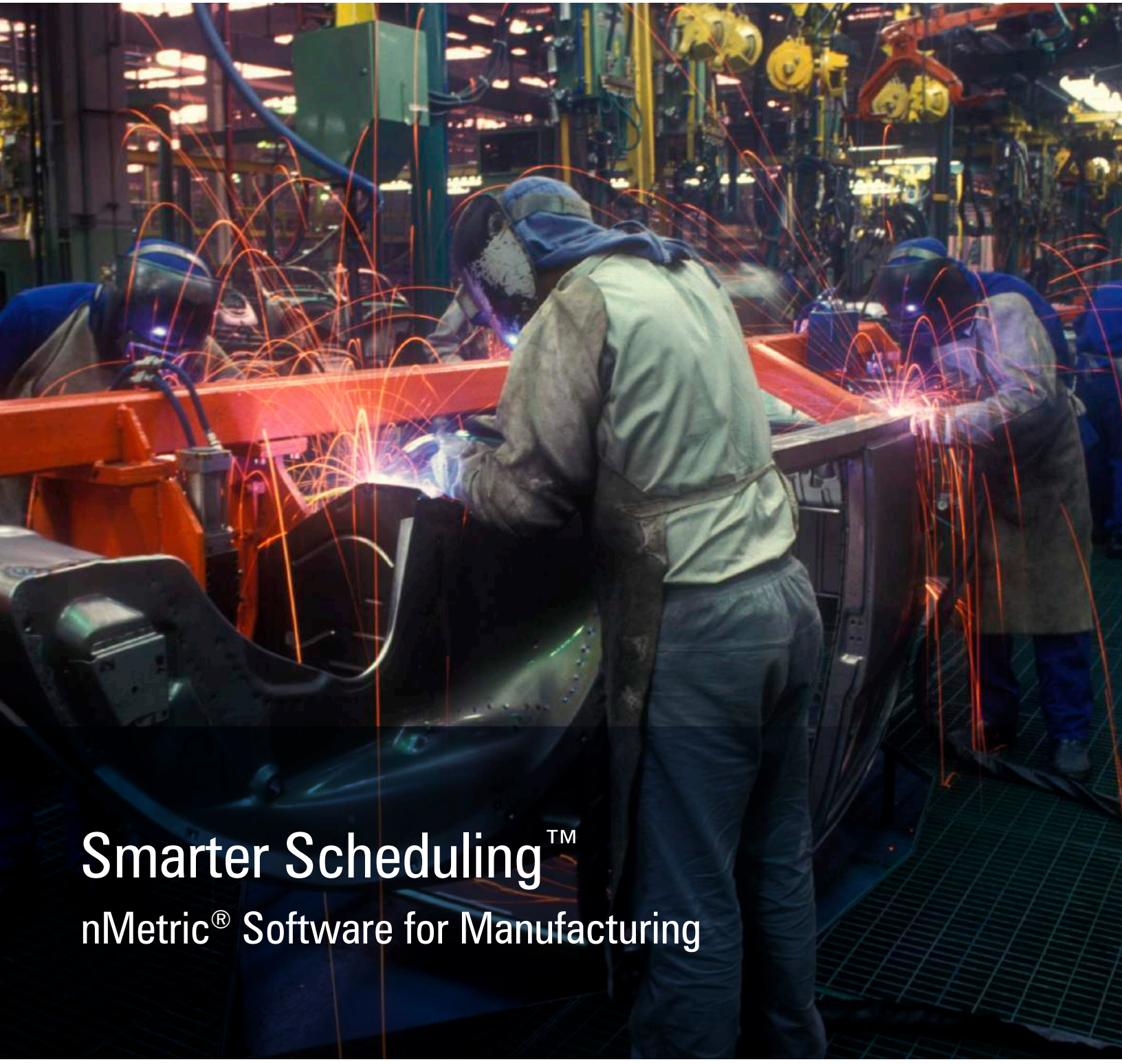


Smarter Scheduling™

nMetric® Software for Manufacturing

nMetric®
Smarter scheduling®

For over 50 years, I've seen the same story in one discrete manufacturing company after another.

Management creates a schedule for production without knowing if the things on that schedule can be done.

Floor workers don't know if they can do what they're supposed to do until the last minute. Many times, they can't. The resulting improvisation exacerbates bottlenecks and creates delays and defects.

Technology, business process and cost-cutting initiatives are implemented to treat the symptoms. The basic problems are never addressed. Some "solutions" actually make the problems worse.

Management is usually unaware of this reality, especially at the corporate level. Meanwhile, the ongoing chaos affects profits, the bottom line and customer service.

American manufacturers simply can't go on this way and succeed in the 21st-century marketplace.

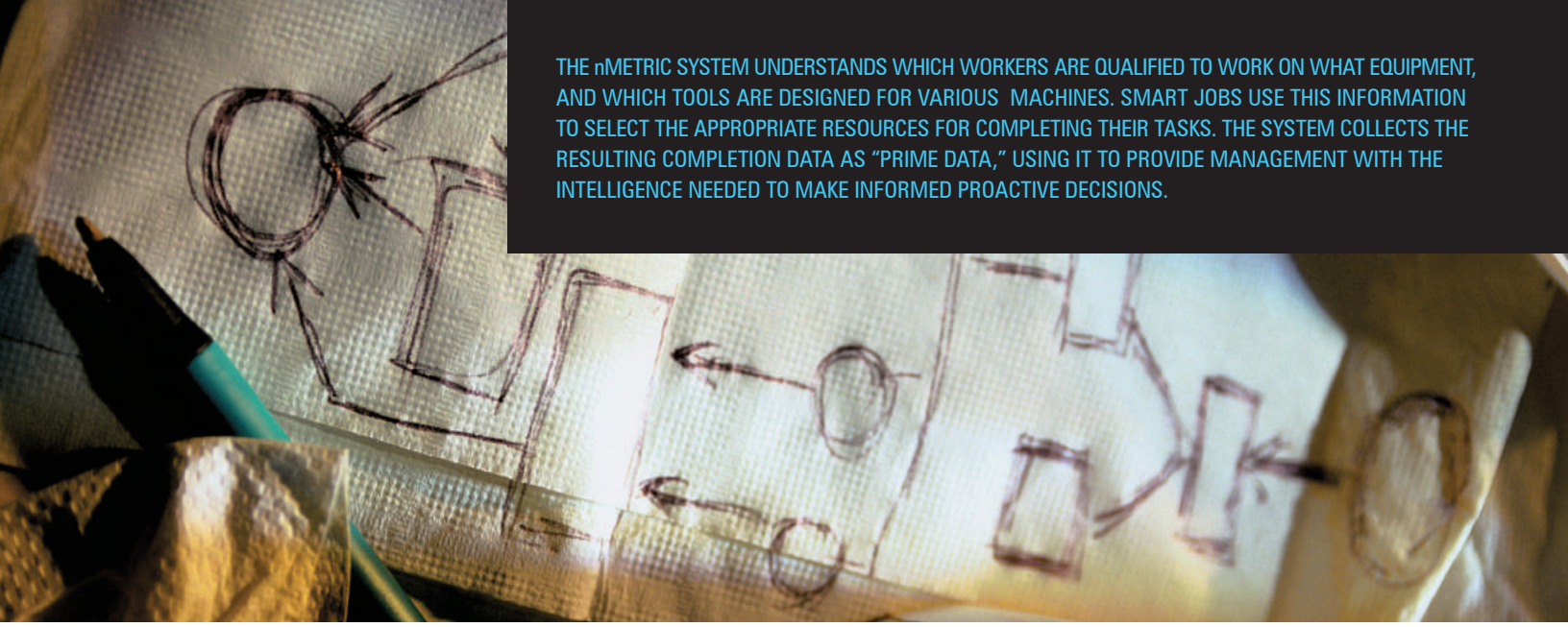
It's time to get smarter.

Robert (Bob) Koski, Founder of nMetric and Sun Hydraulics Corporation

nMETRIC® MEANS SMARTER MANUFACTURING.

It lets you improve on-time delivery, minimize buffers and inventory, increase throughput and dramatically decrease lead times. All while increasing flexibility and responsiveness, so you can move successfully to a demand-driven, make-to-order business model.

nMETRIC'S UNIQUE INTEGRATED SOLUTION GIVES YOU UNPRECEDENTED CAPABILITIES IN SCHEDULING, REAL-TIME RESPONSE TO RESOURCE CHANGES, FORESEEING ORDER CONSTRAINTS, COLLECTING OPERATIONAL DATA, EXTRACTING FORWARD-LOOKING OPERATIONAL INTELLIGENCE AND CONTROLLING THE ENTIRE MANUFACTURING PROCESS.



THE nMETRIC SYSTEM UNDERSTANDS WHICH WORKERS ARE QUALIFIED TO WORK ON WHAT EQUIPMENT, AND WHICH TOOLS ARE DESIGNED FOR VARIOUS MACHINES. SMART JOBS USE THIS INFORMATION TO SELECT THE APPROPRIATE RESOURCES FOR COMPLETING THEIR TASKS. THE SYSTEM COLLECTS THE RESULTING COMPLETION DATA AS "PRIME DATA," USING IT TO PROVIDE MANAGEMENT WITH THE INTELLIGENCE NEEDED TO MAKE INFORMED PROACTIVE DECISIONS.

The birth of the Smart Job®

The basis of the nMetric system was invented at Sun Hydraulics Corporation, a global manufacturer of hydraulic valves founded by nMetric's former Chairman, Bob Koski.

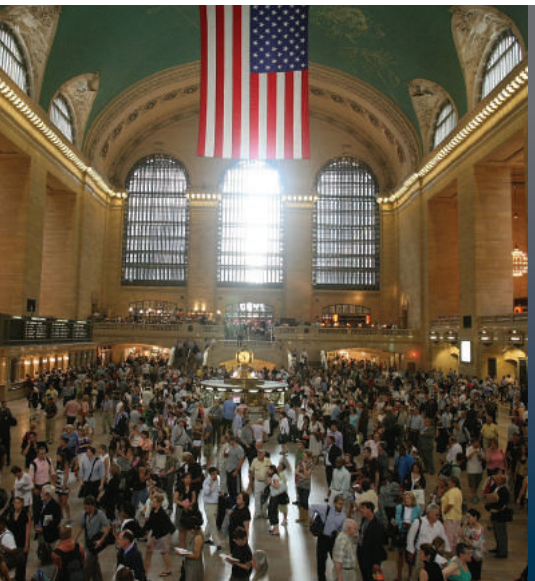
The company faced a number of challenges familiar to anyone dealing with a complex, or "chaotic," manufacturing environment. A high mix of small and large order quantities. Various unique products competing to use equipment and skilled workers. And a high and varying mix of raw materials and purchased parts. On the shop floor, various roving tools could be used on multiple machines – many of which were too large and expensive to be moved or duplicated.

The environment was simply too complex for process software based on a traditional, centralized approach. Even for the ERP software, the dynamic, constantly changing environment made them obsolete almost immediately.

Instead, Koski and Dr. Ken Henderson, an expert in nonlinear optimization, successfully developed a breakthrough concept: the Smart Job®.

It works like this. Every job going through the factory becomes a series of intelligent software objects, called Smart Jobs®. Each Smart Job finds and books the resources necessary to complete itself, including materials, equipment, tools and labor. It understands the relationship between resources and the dependencies of order routing. Knows when each operation has to be completed to stay on schedule. And is aware of its priority relative to other jobs.

In short, Smart Jobs route themselves. And in doing so, they bring highly accurate forward visibility to the factory floor.



YOU'RE ON A BALCONY INSIDE NEW YORK'S GRAND CENTRAL STATION.

It's rush hour. Thousands of commuters are walking every which way. Some are going for coffee before boarding their train, others are getting a newspaper and then a ticket before boarding, and so on.

Taken all together, it's impossibly complex. Yet the commuters succeed in their agendas because each of them is intelligent. They know what they need to do, they communicate, and they respond to changing conditions.

Smart Jobs work the same way. They know which resources they need, how tasks can be ordered most efficiently, and what alternatives are available. They communicate with other Smart Jobs and software objects, reacting to developing situations in real time to achieve their goal of on-time completion.

Seeing reality in real time – and in the future

The use of Smart Job distributed software objects resulted in another significant benefit. For the first time, a manufacturer can get a realistic view of the entire factory floor, in real time. And even see it as it is likely to be in the future.

The nMetric system virtualizes the resources and continually gathers data from the shop floor and Smart Jobs. It combines all of this information into an accurate, multi-dimensional representation of factory operations. You can graphically see all workplaces and timeframes and jobs, and what labor, material and tool resources you actually have available to do them. You know precisely what you can and can't do.

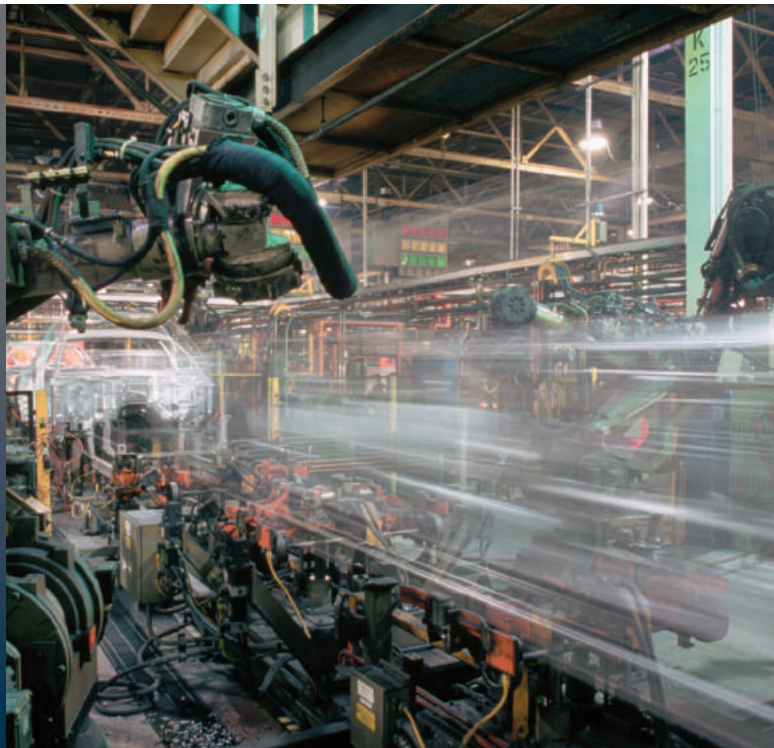
You can also see ahead with a high degree of accuracy. nMetric allows you to quickly extrapolate the effects of floor activities, allowing you to avoid or mitigate problems before they occur.

LET'S SAY YOU HAVE TO PRODUCE 1,000 SETS OF PARTS AND IT REQUIRES THREE OPERATIONS.

Normally, this would mean doing operation #1 for all 1,000 parts, and then operation #2, and so on.

But if you knew exactly how your resources were affected and which were available when, you might be able to do 50 or 100 parts in operation #1, and then start them in operation #2 while the next group of parts are in operation #1. You could end up doing all three operations more or less concurrently, finishing the entire job in little more time than doing just one operation in the traditional manner.

Today, no one in your organization would probably know if you had the resources available to produce the order in this manner. But with nMetric, you do.



Benefits beyond the floor

While the nMetric solution optimizes factory performance, it also has a significant positive impact on other areas of your company.

Engineering can check the "do-ability" of new product designs during the actual design process. Standard costs of processes and resource utilization can likewise be evaluated and optimized to accurately reflect reality and improve efficiency and reliability.

Sales and Marketing will be on the same page as the production team. Everyone can see accurate delivery forecasts at the time of order entry. If an order is canceled by the customer, customer service will know its production status and have the opportunity to charge for the partial production of goods. If an order can't be shipped on time, you can proactively manage customer expectations.

You'll be better able to plan the right investments at the right time by pinpointing the specific resources limiting your productivity. So you can limit the probable financial consequences of excess or under-production for any future date. Production expansion decisions can be more accurately assessed and investments can be balanced against desired customer service levels.

In these and other ways, nMetric will allow people to work better and more accurately both on the floor and across the enterprise.

nMETRIC DELIVERS PROVEN BENEFITS ACROSS THE BOARD.

Financial Benefits
- Lower inventory costs
- Reduced overtime costs
- Limited recall expenses
- Improved cash-to-cash cycle times
- Higher return on net assets (ROA/RONA)
- Lower manufacturing costs as percentage of revenue

Operational Benefits
- Reduced cycle times
- Increased throughput
- Real-time and forward-looking visibility
- Improved percentage of on-time shipments
- Shorter lead times
- Elimination of paper travelers for execution data and tracking

Organizational Benefits
- Increased customer satisfaction
- Streamlined internal communications
- Better vendor/supplier communication
- Everyone working to the same, executable schedule

Smarter is better

nMetric brings order to the traditional chaotic manufacturing process. It becomes a highly efficient, flexible, reliable operation, powered by self-routing, self-supervising Smart Jobs. And guided via a highly visible, highly accurate and continuously updating view of production capabilities.

The nMetric solution lets you respond to customers in record time, keep your promises to deliver, and avoid late penalties.

It allows you to adopt a true make-to-order, Just-In-Time manufacturing model, while dramatically reducing the need for costly buffers and inventory.

It lets you avoid unnecessary or premature capital expenditures because it gives you a better handle on your real needs, both now and in the future.

It helps make your organization much more proactive, making present and future production developments constantly available for review by all relevant parties.

nMetric allows people to do a much better job, with less management, less effort and less hassle in every respect. And in less time, with a much better profit.

There is nothing else like it.

FOR MORE INFORMATION ABOUT nMETRIC OR TO ARRANGE
AN IN-PERSON PRESENTATION, PLEASE CONTACT US AT 888.561.9700
OR INFO@NMETRIC.COM.

nMetric® White Paper: Transforming Discrete Manufacturing

Introduction

nMetric® is a real-time, real-world manufacturing scheduling software system for discrete, complex or "chaotic" environments. nMetric software creates a virtual replica of your production environment. It breaks down customer orders into their routing components and creates a Smart Job® for each step, which identifies the attributes of the resources it needs and routes itself to its most efficient completion using a probabilistic, backward-chaining process. The system framework keeps track of each resource's capability attributes and the compatibilities of those resources, sets the boundaries of resource availability, and maintains the rules for Smart Job priority negotiations.

The nMetric system provides multi-dimensional representations of the demand and supply of resources at all specific work centers in the context of time. The ability to visualize actual plant floor conditions and extrapolate future consequences allows users to more efficiently prepare for various alternatives, use resources more effectively, realize on-time shipment of products, increase staff productivity and reduce hassle throughout the manufacturing process.

Through its integration tool set, the nMetric system connects to existing enterprise systems to extract bill of material, routing and order data to create Smart Jobs®. Combining this information with operational real-time completion data, nMetric's solution provides increased operational efficiency, not only in the plant, but throughout the company. The solution is web-based and provides demand visibility to shop floor personnel, Customer Service, Purchasing and executive leadership through secure portals, for increased real-time information sharing throughout the organization.

Background

The ERP, MRP, scheduling and other major IT systems currently used by nearly every discrete manufacturing company are deterministic. They view the present and future in the same manner as the past. In actuality, of course, the present is a moving point in time, which can not be "frozen" and must be constantly updated, while the future is actually a number of multiple alternate sequences of probable events.

One example of this deterministic flaw is the notion that future events can be scheduled in detail, in advance. In fact, both known and unknown variables introduce uncertainty which defy precise detailed scheduling. These variables, including unplanned outages, out-of-spec materials, breakage or absentee workers, frequently produce bottlenecks and resource constraints or shortages that require real-time schedule revisions. In most organizations, the ability to report or willingness to admit that schedule revisions are necessary is awkward and often poorly received. As a result, the computer system's view of floor operations ends up quite different from reality.

Current scheduling practices seldom compare, and sometimes do not even consider, resource commitments made versus actual resources available over a finite period of time. Traditionally, allocations are made against historical capacity and result in an arbitrary production target, either in dollars or mixture of product units. Some ERP systems assume infinite available resources for each order, others assume a fixed capacity model based on a theoretical limit and, like other systems, have no knowledge of how real-time events have changed the actual capacity or resource availability a company has. With many systems, attempts to measure capacity limitations due to resource constraints typically utilize an iterative process – one that requires so much computer capacity that it is run in batch mode and, therefore, never current, except in a very general and approximate sense.

In complex manufacturing environments, there is usually a high mix of products, orders with wide quantity swings from large to as little as one unit, and a shared set of resources to produce everything. Existing systems rarely consider real-

time changes in actual schedules. Since they are not connected to the shop floor in real time, production is presumed to always be proceeding according to plan. As a result, most production schedules include operations that were supposed to have been completed but were not, and the subsequent departments are left uninformed, disrupting manufacturing operations. Deterministic systems result in underutilized major resources (such as fixed machines and their extensive tool racks) and heavy duplication of floating resources (such as tools, fixtures and inventory), yet still do not achieve on-time production.

The centralized nature of most major IT systems also works against them. The sheer quantity of data involved in planning the utilization of every resource in the production of a product demands inordinate amounts of computing power when traditional forward-chaining programming approaches are used. It is a long path from the product back through all its sub-assemblies, components and resources to the work center, and most hardware systems cannot follow that long trail in a reasonable amount of time – let alone consider any of the alternate probable paths to each branch of the trail.

Even when a product is defined in enough detail to plan all resources back to the work centers, the tendency is to "freeze" the processes for producing that product. No further improvements will be made in production, safety, hassle factor, consistency or costs. Benefits of new production techniques will be lost. The organization becomes a target for competitors who can learn to employ better production methods.

The above are just a few areas in which current IT systems are inadequate to deal with the ever-increasing complexity of manufacturing multi-component products, and to manage effective resource utilization overall. There has been an enormous and unmet need for a technology-based solution that can provide scheduling and optimization in complex discrete, or chaotic, environments.

nMetric Smart Jobs

As opposed to traditional systems, nMetric operates through a decentralized computing environment using multiple intercommunicating software objects, or Smart Jobs, that contain the routing steps and component tasks required to produce a specific order. Smart Jobs recognize each deliverable unit in the order as a component of the whole. This granularity allows a Smart Job to book requirements at a routing step and resource level, separating the set-up and run-time requirements at some machine work centers and allowing the capture of lot, serial number, "how-built" and other prime data. Objects can be distributed over multiple processors to scale processing capacity to requirements.

Smart Jobs are tailored to their specific tasks. For example, some may contain fairly simple steps requiring only a common assembly work center and worker, while others have more complex requirements for a specific type of machine, a particularly skilled worker, a one-of-a-kind tool, specialized raw materials and a specific sub-assembly completed and staged. The more complex the requirements, the more limitations in the probable options for completion. Additionally, all Smart Jobs are equipped with their routing relationship and ship date requirements, providing negotiating power for resource priority with other Smart Job objects.

Smart Jobs are able to respond to requests from other objects and, therefore, to the uncertainty of future events. Communication of demand and supply between them is governed by the system framework, which provides physical boundary rules (overlap percent and transport or wait time limitations) as well as the work center and resource attributes available to sync with the embedded requirements. Each Smart Job seeks out its "best path" and reserves the resources required to complete its mission on time. If preferred work centers are not available, they search for alternatives and negotiate with other Smart Jobs to reserve the resources needed. As the assigned time approaches "Now", the level of uncertainty and alternative paths are narrowed until, at Now and continuing into the past, only the single path chosen is displayed with 100% certainty.

Each reserved time span must accommodate previous Smart Jobs. Subsequent Smart Jobs are notified so operational linkage and overlap rules are not violated. If the order is in danger of late completion, Smart Jobs will use their priority status to negotiate with jobs from other orders for earlier resource reservations. As additional orders are added, jobs

are completed, material/resource availability changes, worker schedules change, tools break and/or machines become unavailable, Smart Jobs also negotiate with one another to find "new best paths" to on-time completion, with the status of all orders relayed to the system in real time.

Outsourced intermediate routing steps are tracked and scheduled like any other. A Smart Job arranges itself according to the outside vendor's specific attributes as it would with any work center, and data is collected on the shipping and receiving of that job to that vendor. Other Smart Jobs monitor its status as they would any other job.

As Smart Jobs are completed, the nMetric system continually gathers data concerning what machine, by whom, with what tools and which materials the Smart Jobs were produced. Also collected are the start and completion times, unit qualities, any operational quality data or operator comments applicable to that Smart Job. Variances between work centers in yield, cycle time, raw material availability, capacity utilization and order on-time completion KPIs are displayed in real time as information is added.

Transparency of Real-Time Operations

If sufficient resources are not or will not be available, the system notifies management of the shortfall and gives a best-can-do production schedule based on current resource availability and requested completion time to meet the entire customer order. Management can then take proactive steps to alleviate the contentions, if possible.

The nMetric system facilitates this process by providing a dynamic, moving, multi-dimensional visualization of data gathered from software objects and relevant systems. This detailed picture of shop floor reality allows a manufacturer to see what can and cannot be done given existing resources, work centers and time.

The nMetric display shows summary and drill-down graphics identifying work centers, tools and personnel that are scheduled with high capacity utilization rates. The time axis allows users to scroll forward and backward from the real-time Now-line, to as distant a future scheduling horizon as desired. The vertical axis shows the user's choice of work centers, tools, people and materials, displaying the demand for those resources across the scheduling horizon. Color and icons in each span provide alerts to special circumstances involving that job span. Contentions and bottlenecks are visible and clear. Management can then choose to add overtime to work centers and/or people resources, and tools and/or skill sets and materials can be purchased, expedited, developed or duplicated if time allows. nMetric also allows management to manually optimize the Smart Job scheduling process through drag-and-drop manipulation of Smart Jobs, configurable operational overlap rules, transport time matrices, Smart Job grouping tools, order management tools and other features and toolsets.

As jobs are completed, they move into history and the time blocks for completed jobs move off the left side of the Now time axis. As new jobs are added, reservations are made in a work center job queue as they are in the other queues for all resources required; in this process Smart Jobs are shifted in a queue or moved to other work center queues. If a work center (e.g., a machine) is shut down, the job queue for that work center stops moving and the job queue gets pushed to the right on the time axis. Often this will cause an automatic rearrangement of Smart Jobs as they search for more time-appropriate resources and delays initiate rescheduling of dependent Smart Jobs. Additionally, an event-based alert can be sent to all necessary personnel as required.

Within this multi-dimensional presentation, users can blend and blur the view of multiple axes in order to examine groupings. For example, resources can be grouped into "all drills" or "all tools" and the system will display these groupings and highlight any contentions within a group. Work centers can be grouped to show demand and supply for a whole department rather than individual machines.

Through its display, the system encourages proactive decisions. It allows users to react to future events by selecting from alternative actions and encourages intelligent procrastination, so decisions that narrow alternatives can be made as late as possible for maximum flexibility.

Benefits of Decentralized Computing

Conventional MRP systems view products as a combination of materials and, therefore, plan only the need for those materials. In contrast, the nMetric system views products as a combination of tasks and many different types of resources, including materials, tools, fixtures, labor, consumables, production equipment, etc. By defining these physical tasks and resource features rather than controlling the "process" of producing parts, a backward-chaining way-station is built in the long path from order initiation to product, adding automatic flexibility to production processes. Frozen processes are avoided because the system allows the shop floor to be viewed in terms of its capability to accomplish certain tasks, rather than its capacity to produce certain products. As a result, skilled operators have the flexibility to easily introduce new production processes, rather than being locked into processes that are "designated" as the ERP/MRP routing.

With Smart Jobs, there is no need for computing hardware with the power to centrally calculate all the myriad paths and possible alternative paths for every job in the plant at every turn. Instead, the nMetric system receives prime data from the floor and knows which workers have the capabilities to operate specific machines, which tools are fitted to specific machines or used in specific work centers, and which materials are appropriate for various machines or work centers. Instead of the system determining what is done, when and where, the nMetric system tells the Smart Jobs what they can not do, and the Smart Jobs choose what they can and must do.

As a Smart Job progresses, fewer and fewer process paths are possible, further decreasing the need for computing power. The system also calculates in advance the demand for specific tasks based on current customer orders. As a result, the system's critical real-time scheduling calculations are reduced to comparing the demand for tasks with the supply of tasks, a function well within the capability of common computer environments.

Summary

The nMetric system transforms discrete, complex manufacturing into a highly efficient and reliable operation, powered by self-routing, reactive Smart Jobs and a highly visible, highly accurate and constantly adjusting view of production capabilities. Schedule adjustments can be made "on the fly" and be seen by users in real time. Potential bottlenecks due to contentions for resources are displayed for analysis and resolution both in advance and during the production process. The organization becomes much more proactive because present and future production developments are constantly available for review by all relevant parties inside and outside the company. As each new order or request enters, and each shipment or operation on a part is completed, a new world of requirements unfolds for analysis, minimizing reactive and time-consuming iterations and providing real-time visibility of the production environment to every area of your enterprise.