ROBOTICS TECHNOLOGIES—A KEY ELEMENT IN ACHIEVING MANUFACTURING EXCELLENCE

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This issue of the *AT&T Technical Journal* focuses on robotics technologies. We use the term *robotics* here to encompass a broader range of technologies than is covered under the usual interpretation. We include not only the physical sensing and mechanical technologies that evoke notions of anthropomorphic machines, but also systems engineering, software, communications, and computing technologies.

Perspective

Robotics technologies—including the physical sensing and mechanical technologies, plus systems engineering, software, communications, and computing—enable us to achieve a high degree of flexibility and versatility in automating our manufacturing processes. Automation of this type is an important factor in AT&T's ability to achieve and sustain a high level of productivity and quality in our manufacturing operations.

This is not to say that automation—flexible or otherwise—will, by itself, lead to world-class manufacturing. (By "world class," we mean being competitive with the best manufacturers in the world.) Automation must be applied in the context of an overall program of manufacturing excellence, a program that encompasses (in priority sequence):

- Systems engineering and re-engineering of current manufacturing operations for globally optimized economy and effectiveness.
- Product design for manufacturability.
- "Enabling" automation required to accomplish "supra-human" manufacturing—the manufacture of products that requires capabilities outside the human range, such as very high precision.
- Re-engineering of information systems, to ensure that they effectively support the needs of the manufacturing enterprise.
- "Cost-reducing" automation, to achieve higher levels of quality and lower the cost of achieving the desired quality and, sometimes, to reduce labor costs.

Implementing automation outside the context of such an overall program for manufacturing excellence leads to "islands of automation" that usually do not deliver the desired productivity benefit, and sometimes are counterproductive. The latter result may occur even if the automation project seems to be technically successful, because we may be automating a function that we would implement much differently under a system-optimized approach.

For the most part, then, AT&T's work in robotics is conducted with application in our factories as an objective, and applications of this type yield the desired benefits only in the context of an overall program of manufacturing excellence. Within that context, the mastery and exploitation of robotics technologies can and do have significant impact on our manufacturing capabilities, productivity, and quality.

For AT&T to achieve and sustain a world-class manufacturing capability, there is no question that we must be able to apply these technologies effectively in our factories. New products, such as very-fine-pitch surface-mounted devices, increasingly demand supra-human manufacturing capabilities. Also, the drive toward just-in-time (JIT) and total-quality-control (TQC) manufacturing philosophies puts an ever-greater premium on flexibility and tight process control in our manufacturing processes. Our continuing work in robotics technologies, some of which is reported in this issue, is a key element of AT&T's efforts to meet challenging problems such as these—challenges that we must effectively meet to be a world-class manufacturer of leading-edge communications and computing products.

In This Issue

Much of AT&T's work in areas of product-realization methods, systems engineering for global optimization, design for manufacturability, and the architecture of information and control systems and their implementations has been described previously.[1,2] In this issue, we describe some of our recent work in technologies closely related to robotics and flexible automation, and our factory experience in using these technologies. The papers cover a broad range of specific technology issues, a direct result of our view of robotics as a broad umbrella for several related technologies.

Flexible Automation. Consistent with our focus on flexible automation in manufacturing as a key target area for the use of robotics technologies, several papers deal with flexible manufacturing workstations and issues associated with their design and operation.

Lilienthal et al.[3] describe a multielement robotic workstation, which features a Cartesian workspace and other attributes that make it attractive for highly accurate light-assembly manufacturing.

Decelle[4] describes initiatives at AT&T's Merrimack Valley Works to apply robotics technology for inserting components into printed circuit boards. Strip[5] describes technologies that improve robotic assembly by incorporating active compliance and force sensing in the control strategy. He also outlines guidelines for their application.

Machine Vision. Berk, Judd, and Wisniewski[6] describe three different workstations that were developed for use in the manufacture of optical data links. Each of these workstations uses machine vision to advantage. Machine vision—even when it isn't tightly coupled to a robotic manipulator—can enhance manufacturing quality and overall process control. The paper by Ray[7] describes a use of machine vision for these purposes.

Intelligent Systems. Achieving and maintaining a world-class level of cost-effectiveness and quality in manufacturing operations increasingly requires use of highly "intelligent," software-intensive machines and systems.

Cox et al.[8] identify several issues and problems that are relevant to software for real-time robotic systems. They also describe useful approaches for dealing with these issues and problems. Andersson[9] describes techniques for introducing intelligence into robotic systems to allow them to cope quickly with a dynamic environment. These techniques vary from low-level control algorithms through "expert system" approaches.

Material Management. For the most part, the basic value added by a modern manufacturing operation takes place within workcells, where parts and materials are transformed into products. But the operation's overall effectiveness depends critically on systems and methods for storing and moving components, materials, work in process, and finished products. Pulat and Hewett[10] describe experiences at AT&T's Oklahoma City Works in implementing advanced technologies for moving, storing, and controlling the flow of material in a complex manufacturing environment.

Summary

While these papers represent only a sampling of AT&T's ongoing work to develop and exploit robotics technologies, they provide solid evidence of the importance of these technologies in driving toward ever-better manufacturing productivity and quality. But their value can be fully realized only in the context of a "rationalized" manufacturing environment—one where:

- All operations are engineered for globally optimized cost-effectiveness.
- Sound architectures and supporting systems for comprehensive information systems are in place.
- Active, effective efforts are ongoing to assure the high quality of incoming parts, materials, and product designs.

In AT&T's programs for manufacturing excellence, we are aggressively pursuing the realization of such rationalized environments throughout our manufacturing operations. As we continue our rapid progress in this direction, robotics technologies—such as those highlighted in this issue—will become even more important to our continuing ability to realize our goals for manufacturing excellence.

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Biographies (continued)

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