Machine tools are used in hundreds of thousands of plants and shops to cut and shape metal parts and pieces. The interface between the cutting or shaping tool and the material being worked almost always gets hot. In most cases, a coolant is directed onto the interface area to take away enough heat to allow the job to be performed.

High Heat Degrades Machining Quality
Even with the coolant, the machine tool itself often becomes warm enough to change shape slightly, and the accuracy of the machining operation degrades. The result can be a finished part that fails to meet specifications. What would have become a salable part becomes scrap metal, and some high-precision parts cannot be made at all.

Thermal-Error Compensation
With ATP funding, Saginaw Machine Tools — a small, privately held company founded in 1983 to build precision computer-controlled machine tools for high-volume manufacturing — together with researchers at the University of Michigan, developed a solution to the heat problem. Their technology monitors the temperature gradients in computer numerically controlled (CNC) machine tools and alters the control process dynamically (while the machine is working) to compensate for heat-related changes in the machine tool as the part is being worked. When the new technology is incorporated into machine tools, the result is higher-quality parts.

The technology uses a laser system to measure machine geometric and thermal errors and heat sensors to monitor temperatures near the interface between the cutting tool and the metal being worked. A computer program, using a thermal volumetric error model, processes the laser and sensor data and sends corrective instructions to the machine tool in real time, as it shapes the metal. Use of this thermal-error compensation technology enhances the accuracy of CNC machine-tooled products.

Better Precision for Machine Tools Through Thermal-Error Correction

Customers manufacturing high-precision parts realize productivity improvements of 10 percent to 30 percent . . .
by fourfold to fivefold as measured by spindle drift (shifting of the shaft, in a lathe or other machine tool, that holds the piece being formed), at a commercially viable cost.

First Products to Market
At the end of the ATP funding period, additional development work not originally foreseen by the company remained to be done. Saginaw continued to advance the technology and has invested as much of its own funds since the close of the project as the ATP put in at the beginning.

Since completing the development work, the company has begun to move its first product, which uses the Accu-System incorporating the ATP technology, into commercialization. By early 1998, Saginaw had developed prototype tools. One prototype was tested by an independent laboratory and pronounced ready for market. Another tool from Saginaw was subjected to a competitive evaluation process by a large tool buyer, in which the Saginaw tool was pitted against tools from seven other suppliers. The results showed that the Saginaw machine with the Accu-System was the most accurate. All in all, 30 characteristics of machine performance were measured, and the Saginaw machine had a weighted average score that was 50 percent higher than the next best machine. On the critical characteristic of spindle drift, the Saginaw machine achieved a two-thirds reduction in drift compared with the next best machine.

By March 1998, Saginaw had received orders from other companies for eight machines priced at more than $200,000 each. Orders for several dozen additional machines of the same type were expected over the next several months.

. . . most machine tools that make high-precision parts are likely to be improved in the long run.

Productivity Improvements
Users of the technology are able to take advantage, at reasonable cost, of a substantial increase in the accuracy of their machine tools, improving the precision of the workpieces the machines produce. Customers manufacturing high-precision parts realize productivity improvements of 10 percent to 30 percent because of reduced requirements for part testing and rework.

The number of potential applications is large. Because the Saginaw equipment is now in use, other manufacturers
may imitate the technology. The company has concluded that none of the technology is patentable, and it is likely that competitors will be able to imitate its methods. Consequently, most machine tools that make high-precision parts are likely to be improved in the long run.

If Saginaw had not received the ATP award, company officials say, it would not have done the project. Being primarily a manufacturing company, it did not have a substantial research and development capability. While working on the ATP project, Saginaw collaborated with the University of Michigan on a subcontractor basis to extend the company’s research capabilities. In addition, officials say, having the ATP award helped Saginaw win a subsequent $1 million award from the Defense Advanced Research Projects Agency for a related project.