EXECUTIVE SUMMARY

Wohlers Report

Rapid Prototyping & Tooling State of the Industry Annual Worldwide Progress Report

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Introduction

This eight-page document provides an overview of the information published in *Wohlers Report 2000*. The 200-page report includes 28 charts and graphs, 26 tables, and 80 photographs and illustrations. The softbound publication focuses on many important facets of rapid prototyping and tooling, including the industries being served, applications, revenues, unit sales, and forecasts. It also provides current information on trends with regards to service bureaus, advanced approaches to tooling, system manufacturers worldwide, RP stocks, and new developments in the U.S., Europe, and Asia. The report covers research and development activities, trends in CAD and the Internet, RP materials, medical modeling, and reverse engineering. The report concludes with a review of the future of rapid prototyping, where it's headed, and what to do.

Rapid prototyping (RP) refers to the physical modeling of a design using a special class of machine technology. RP systems quickly produce models and prototype parts from 3D computer-aided design (CAD) model data, CT and MRI scan data, and data created from 3D data collection systems. Using an additive approach to building shapes, RP systems join liquid, powder, or sheet materials to form physical objects. Layer-by-layer, RP machines fabricate plastic, wood, ceramic, and metal parts using thin, horizontal cross sections of the computer model. Some argue that free-form fabrication (FFF) more accurately describes this class of technology, particularly as its applications expand beyond fast prototyping.

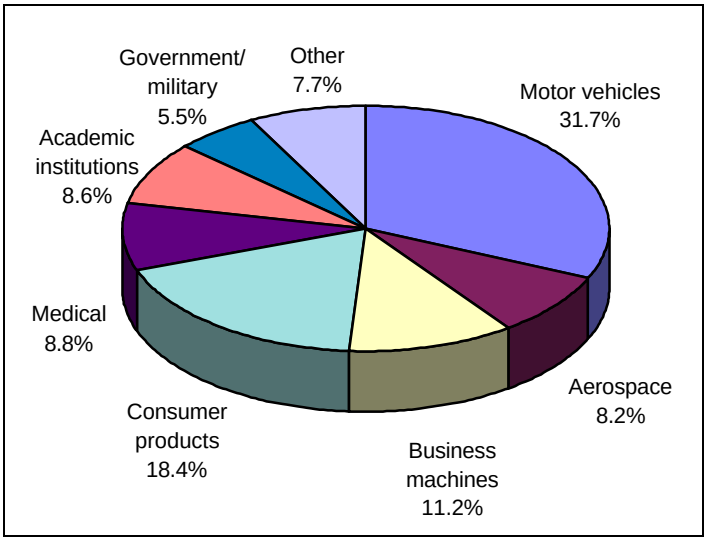
Manufacturing organizations use RP to produce models and prototypes of injection-molded parts and metal castings that go into everything from copy machines, computers, and cellular phones to automobile instrument panels, airplane subassemblies, and medical diagnostic equipment. RP acts as a lubricant that helps to smooth and streamline the product development process. Most companies use it to help improve time to market. As a visualization tool, RP helps companies reduce the likelihood of delivering the *wrong* product, or a poor quality product, to the marketplace. For some, it may be helpful to view rapid prototyping as a journey, not a destination—a strategy, not a technology.

Methods, processes, and systems for *rapid tooling (RT)* are also developing, many of which are new and not well understood. As an emerging technology, the definition of RT is often debated and not clearly defined. Most would agree, however, that RT is driven from an RP process—the key to making it rapid. The digital data from a CAD solid model and RP processes are important elements of rapid tooling. An indirect approach to RT accelerates the tooling process using RP patterns that are, in turn, used to produce molds. Another approach to RT is to produce tooling components, typically custom mold inserts, directly from an RP process such as selective laser sintering.

Methods of RP and RT are having a profound impact on the way companies produce models, prototype parts, and tooling. Also, they are impacting the lives of many individuals that have chosen to use, manage, teach, or develop some aspect of RP or RT. Product designers, manufacturing engineers, researchers, and countless others are hard at work trying to further understand these technologies and the increasingly prominent role they will play in their jobs, organizations, and business processes.

Industries being served

Companies that use rapid prototyping cut across most manufacturing industries. The following chart reflects the major industrial sectors that are now taking advantage of the technology. Similar to past years, the motor vehicles industry leads all others in the use of RP.



Source: Wohlers Associates, Inc.

The consumer products industry has established itself as a major market for RP products and services. The "Other" category includes industries such as professional sporting goods, non-consumer and non-military marine products, and other industries that do not fit into the named categories.

Fifteen RP system manufacturers and 44 RP service bureaus provided the data used to produce this chart, as well as others that were published in the full report. These 59 companies provided estimates based on knowledge of their customers' industries and applications.

Encouraging growth, challenges ahead

In early 1999, industry observers were surprised by the sharp decline in RP sales and services. Many had suspected that 1998 was not a particularly good year, but few had braced themselves for the results that were published in last year's report.

Much has changed in the past year. Product sales have improved, and service bureaus, overall, are doing better. The unsettling stories associated with Plynetics Express, Compression, and Formation are not forgotten, but they have faded. Many companies are now looking forward and are putting the past behind them.

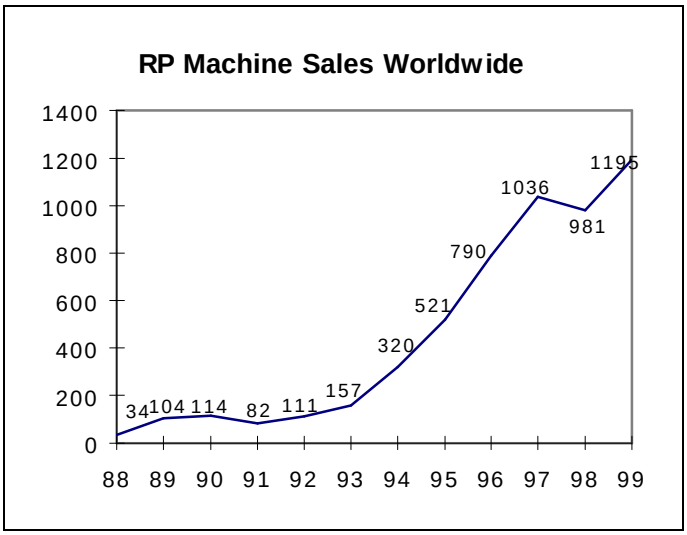
A new measurement has been added to this year's report, a comparison of the annual production of RP models and prototypes. Last year, all companies worldwide that used RP equipment produced an estimated 2.34 million parts. This is up about 26% from an estimated 1.86 million parts produced in 1998.

Although there was an overall improvement in the state of the RP industry, the results for individual companies were mixed. All of the top systems manufactures produced an increase in unit sales. For some, this translated into

an increase in both revenue and profit. Others found that increasing the number of systems sold did not lead to financial gain. Collectively, the companies that supply the RP industry generated an increase in the revenue for both products and services.

Revenue and unit sales growth in the industry have not returned to early- and mid-1990 levels, but the percentages are back in the double digits. Given that the industry has entered its teenage years, it's unlikely that we will see the rapid growth of the past without a technical breakthrough in the ratio of price to performance. Even so, new technology follows a somewhat predictable growth curve as the concepts and practices are adopted. It is not unusual for a technology to experience rapid growth, only to be followed by a period of slower development. RP has reached this period.

RP's growth and success are also affected by the state of the CAD industry. CAD solid modeling, the fuel for RP, has begun its dramatic growth phase. Experts predict 80% growth in solid modeling for the next couple of years. With this growth, RP will have many new opportunities for sales of systems and services.



Source: Wohlers Associates, Inc.

The early success of the service bureaus (SBs) has negatively impacted the RP market. Having reached a temporary level of saturation in 1998 and early 1999, the SB market became highly competitive. Prices of RP parts were driven to an all-time low and corresponding profit margins vanished. This led to the demise of some SBs, which resulted in many RP systems available for purchase. The rock-bottom prices for RP parts, coupled with the availability of used equipment, contributed to a decline in the demand for new machines.

Companies prefer technology that is more mature than most RP systems on the market today. Many people in the industry are asking for machine technology that is less expensive to buy and maintain and easier to use. Indeed, RP system prices and the overall cost of ownership must drop further. Recently, a newcomer has introduced machine technology that may prove to be one of the most important developments in the history of the RP industry. The technology deposits and cures photopolymer by ink jet printing—a method that many

thought was impossible. This and other developments will force the price of systems and services to decline further in 2000 and 2001.

Growing list of RT methods

There is tremendous interest in rapid tooling (RT) solutions. Whether the application is prototype, bridge, short-run, or production tooling, RT presents an opportunity to slash both time and expense.

The list of RT developments that have been announced to date is impressive, but few are ready for broad-based commercial use. Each of the processes comes with a set of strengths countered by limitations. Typically, this results in solutions that cater to niche applications. Yet, because of their possible impact, these developments are causing a flurry of inquiries from companies in the Americas, Europe, Asia, and other developed regions.

Manufacturing companies are working hard to determine if the time is right to phase in one of these new approaches. Some of them believe that not only is it time to act, but the action entails creating their own solution. Companies are developing RT methods for in-house use with no intention to license the technology or make it commercially available. These efforts are directed towards the development of an approach that offers a strategic advantage over their competition.

Beyond cost and time reduction, RT offers a potential benefit that cannot be realized with conventional machined tools. With RT, it is possible to embed conformal cooling channels within the mold. These channels allow coolant to pass through the mold in a pattern that conforms to the geometry of the mold cavity. Compared to the straight-line channels in machined tools, conformal cooling can remove hot spots in the mold to reduce injection-molding cycle times. Cycle time reduction can have a significant impact on part cost and production rates.

Climbing the chasm walls

In the past year, there have been many positive developments. Questions regarding the sustainable future of rapid prototyping are no longer in the forefront of thought. Today, the questions center on what rapid prototyping will look like in the future and how long will it take to develop.

In 1999, the rapid prototyping embers were rekindled. Unit sales of 1,195 rapid prototyping machines worldwide yielded 22% growth and a cumulative total of nearly 5,500 systems in 53 countries. These machines produced an estimated 2.34 million models and prototype parts. Patent applications for RP developments have reached an all time high with 208 in the past two years.

Encouraging growth figures have led to renewed optimism for the industry. However, this optimism needs to be balanced with caution. Rapid prototyping has yet to pull itself from the "chasm," and this chasm is filled with barriers, obstacles, and land mines. Rapid prototyping has, in effect, placed the ladder against the wall of the chasm and has begun to climb from its depths.

RP is developing at both ends of the product development spectrum. At the front end, 3D printing for concept modeling shows tremendous promise. At the back end, the technology is evolving from prototyping and tooling to rapid manufacturing.

Rapid manufacturing (RM) may be the next frontier. Already, some companies are beginning to use RP-driven processes to manufacture end-use parts, albeit in relatively low quantities. It's unlikely that RM will ever reach the production capacity of processes such as injection molding or sheet metal stamping, but for some companies, this may not matter. Not all manufacturers produce and sell in volumes of millions, or even tens of thousands.

The RP industry has moved from a technology orientation to an application orientation, which means that vendors must demonstrate applications, not technology. Delivering applications is an important step in crossing the chasm since the pragmatic buyer seeks to have "whole solutions" delivered, not just a set of tools. Potential customers want to see more than a technical demonstration accompanied by an example or two of how users apply RP. They want to understand how it can be put to work for their day-to-day jobs. For the industry to cross the chasm and mature, it must meet these and other needs of the customer.

The RP industry will experience dynamic changes in the next few years. The impact of new technologies, process advancements, and the Internet will create challenges and opportunities. For system manufacturers and service bureaus, adaptability, and the speed at which this occurs, will be critical to their success and survival. For users, the coming changes will open the door to greater use and broader application of the technology called rapid prototyping.

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The author thanks Accelerated Technologies, Inc. for its kind support and sponsorship of this publication. ATI is a leading rapid prototyping service organization that helps companies bring better products to market faster. You can reach the company at 512-990-7199 in Austin, Texas, or 859-334-3875 in Cincinnati, Ohio. ATI's e-mail address and website are ati@atiaustin.com and www.acceltechinc.com.

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About the author

Industry consultant Terry Wohlers is president of Wohlers Associates, Inc., an independent consulting firm he founded in 1986. The company provides technical, marketing, and strategic consulting on the new developments and trends in product design, prototyping, tooling, and reverse engineering. For the past 23 years, Terry has focused his education, research, and practice on design and manufacturing. He has established a tradition of providing high-quality analyses that cover all facets of rapid prototyping (RP) including business, product, market, technology, and applications.

Terry's views and opinions are highly sought after. They come from years of collecting and analyzing market data, coupled with work as a consultant and advisor to major organizations in the U.S., South America, Europe, the Middle East, and Asia. He has been given the opportunity to speak to thousands of engineers and managers and has been a keynote speaker at major industry events around the world. He has authored more than 230 books, articles, reports, and technical papers on engineering and manufacturing automation.

In 1992, Terry led a group of 14 individuals from industry and academia to form the first association dedicated to rapid prototyping. In 1993, the association joined the Society of Manufacturing Engineers (SME) to become the Rapid Prototyping Association (RPA) of SME. In 1998, Terry co-founded the Global Alliance of Rapid Prototyping Associations (GARPA) involving 14 member nations around the world. Its purpose is to encourage ongoing sharing of information on rapid prototyping and tooling across international borders.

How to order the report

In the U.S., *Wohlers Report 2000* is available for $345, which includes Priority Mail shipping. For orders outside the U.S., the price is $395, which includes Global Priority Mail shipping.

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