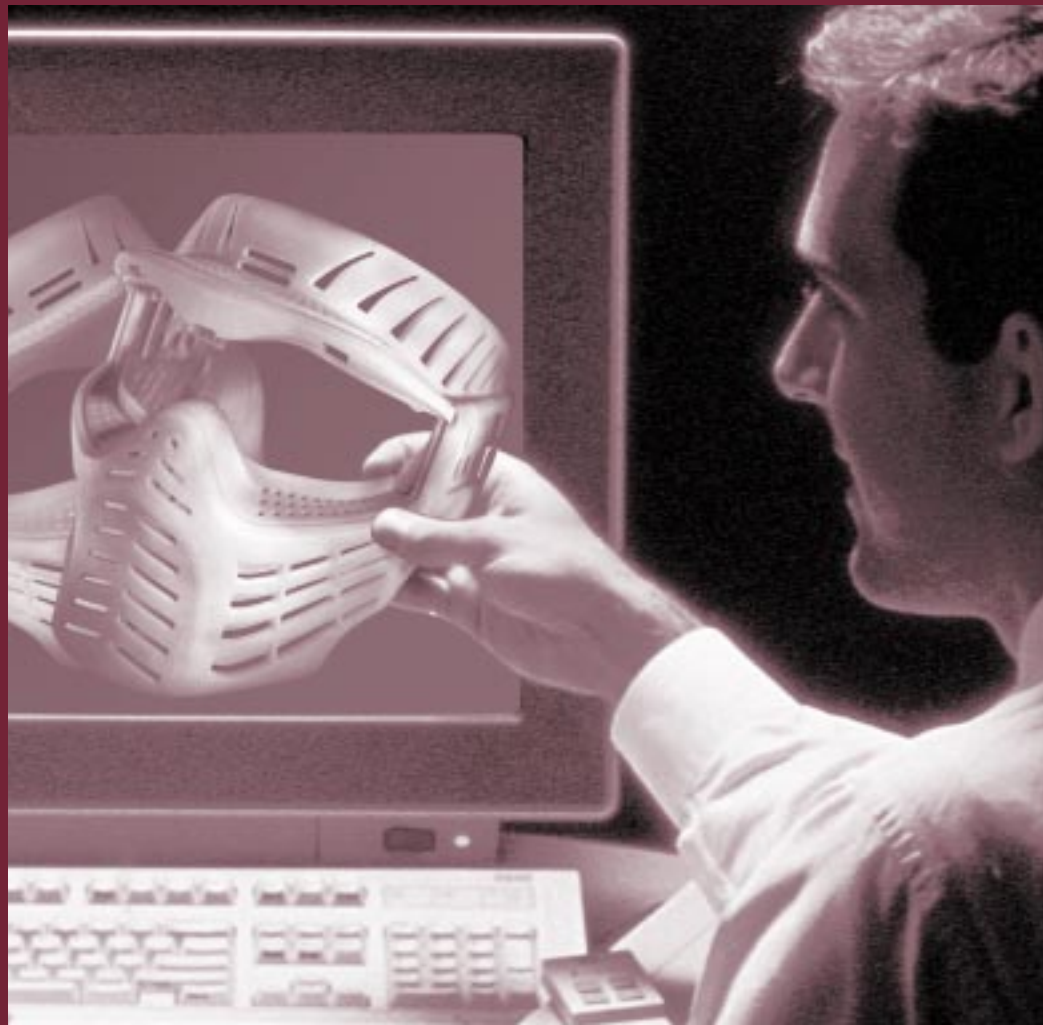


EXECUTIVE SUMMARY

# Wohlers Report

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

Terry Wohlers





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## Wohlers Report 2001

This eight-page document provides an overview of the information published in *Wohlers Report 2001*, a 250-page, softbound publication. The report includes 26 charts and graphs, 32 tables, and 80 photographs and illustrations. The focus of the report is on the 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 regard to service providers, advanced approaches to tooling, system manufacturers worldwide, RP stocks, and new developments in the U.S., Europe, Asia, and other parts of the world. The report covers research and development activities, trends in CAD and the Internet, RP materials, medical modeling, and reverse engineering. *Wohlers Report 2001* concludes with a review of the future of rapid prototyping, where it is headed, and what to do.

## Introduction

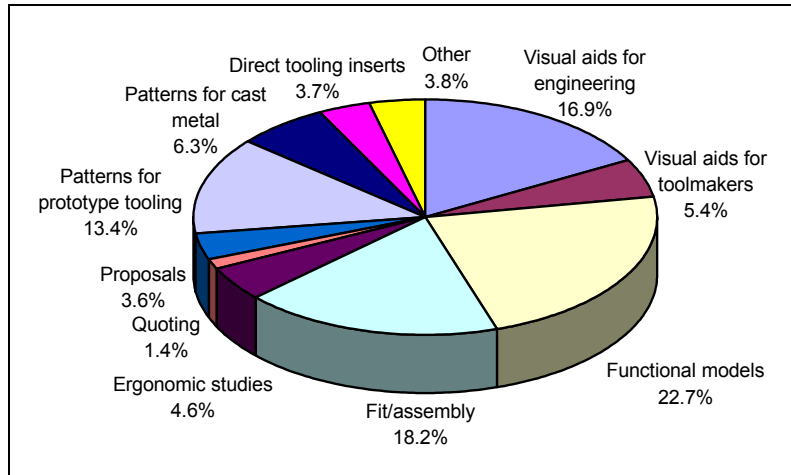
*Rapid prototyping (RP)* refers to the physical modeling of a design using a special class of machine technology. RP systems quickly produce models and prototype parts from 3D computer-aided design (CAD) model data, CT and MRI scan data, and data created from 3D digitizing systems. Using an additive 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.

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.

Rapid prototyping is having a profound impact on the way companies produce models, prototype parts, and tooling. A few companies are now using it to produce final manufactured parts. Some believe this practice, termed *rapid manufacturing (RM)*, will develop into a compelling market opportunity in the future.

## How RP models are being used

The following chart shows how companies are using RP models. Nearly 41% of all RP models are being used for fit and function applications, an estimate derived by adding together the “fit/assembly” and “functional models” segments. About 27% use RP as visual aids for engineering, toolmaking, quote requests, and proposals, an estimate derived from adding together these segments. More than 23% of RP models are being used as patterns for prototype tooling and metal casting, as well as for tooling inserts.



Source: Wohlers Associates, Inc.

Fourteen RP system manufacturers and 43 RP service providers provided the data used to produce the previous chart. These 57 companies provided estimates based on knowledge of their customers’ industries and applications.

The diversity of applications of rapid prototyping is limited only by the imagination. The obvious, conventional applications of the technology are easy to see and appreciate. However, when rapid prototyping is applied to more than one aspect of product development, or it is applied in a manner that creates new ways of thinking and alternative approaches, the power can be unimaginable.

Perhaps the most significant barrier to realizing new applications and powerful benefits is the tendency to resist change. Established processes and procedures are difficult to displace. When forward thinking individuals apply RP in new and exciting ways, it is possible to achieve amazing results.

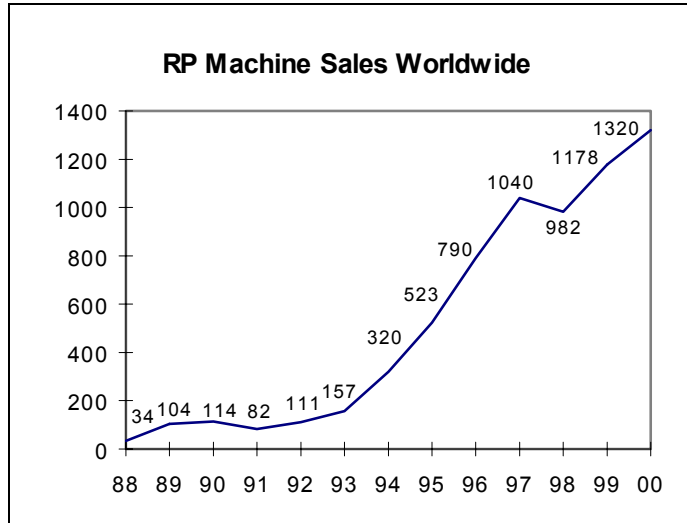
The breadth of RP applications is impressive. The technology has been applied to fields as varied as medicine, architecture, and forensics. Examples include:

- Burn masks with better fit that improve recovery.
- Components for the world’s smallest autonomous robot.
- Recreation of a murder victim’s likeness.
- On-demand creation of components for a self-designed droid.
- Action figures for Hollywood films.
- World-class sculptures that were previously impossible to produce.
- Skulls of accident victims to prepare for reconstructive surgeries.
- Models printed in full color, revealing areas of stress through finite element analysis.

If change is welcomed, it is inevitable that many more unimaginable applications of RP will develop.

### Industry growth

The RP industry has experienced a number of up and down years over its history. Many years have been stellar, both in unit sales and revenues. Other years have been sobering and even disappointing. 2000 was neither stellar nor disappointing. It was a year of acceptable, moderate growth.



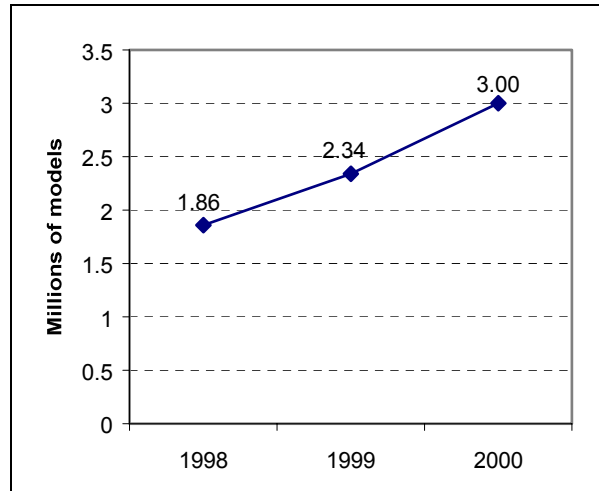
Source: Wohlers Associates, Inc.

The moderate growth rate is a result of the preference for technology that is more mature than most RP systems on the market today. People in the industry are asking for machine technology that is less expensive to buy and maintain and easier to use. To entice more users to adopt RP, system prices and the overall cost of ownership must drop further. In response to this demand, it is expected that the average purchase price of systems will continue to decline in 2001 and 2002.

To survive and thrive, companies such as 3D Systems, DTM, CMET, EOS, and Stratasys must move beyond the established market to find new customers outside of the large organizations and service providers that have implemented RP. This will require a new generation of products that cost much less and perform better than today's offerings.

### Number of models being produced

Despite a moderate deceleration in growth, RP users worldwide produced an impressive 3,004,006 models and prototype parts on their machines in 2000, according to *Wohlers Report 2001*. This is up 28.3% from an estimated 2.34 million parts produced in 1999. This compares to growth of 26% in 1999 over the estimated 1.86 million models produced in 1998.

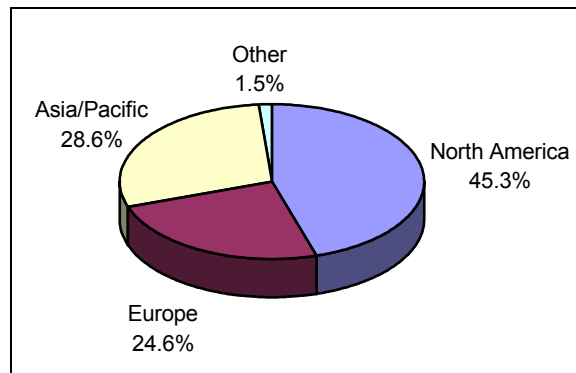


Source: Wohlers Associates, Inc.

On average, two copies of a unique design are built. This means that 1.46 million distinctive parts were produced in 2000. To some, this is a staggering number of parts being produced from a class of technology that has been available for little more than a decade.

### Installations by region

The following chart shows the regional distribution of RP machines installed throughout the world. The estimates are cumulative totals from RP's inception through 2000. The chart accounts for 6,521 of the 6,755 machines that have been sold and installed worldwide.



Source: Wohlers Associates, Inc.

### Service providers

Service providers offer design, CAD, data translation, prototyping, tooling, urethane casting, reverse engineering, and other engineering and manufacturing services. Overall, 2000 was a good year for these companies, especially compared to the 1997–1998 time frame, when many were forced to downsize, sell their businesses, or shut down.

Worldwide, there were 384 service providers operating 894 RP machines at the end of 2000, according to the March 2001 issue of *Rapid Prototyping Report*. Nearly half of these companies are located in the U.S. As has been true in the past, 3D Systems and DTM dominate in installed machines in service organizations.

In early 2001, several service providers voiced a concern over a lack of incoming projects and cash flow. One company was forced to lay off some employees, a first in the company's history. Others are fearful that supply and demand may return to 1997–1998 levels. To compete, some companies have reduced prices significantly, a similar response to the tough times of three to four years ago. Weak earnings and layoffs in the manufacturing sector suggest that this could continue through much of 2001.

## Rapid tooling

The list of RT developments that have been announced to date is striking, but few have seen commercial success. 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 number of investigations from companies in the Americas, Europe, Asia, South Africa, and other developed regions.

Tooling produces billions of dollars in annual revenue. The amount of this market that RT can capture is still unknown. However, Wohlers Associates believes that rapid tooling will grow into a sizeable market as processes are further refined and companies explore ways to make them work.

## The future

For the company or individual focused on a specific application, or the use of a single technology, the pace of development may be disappointing. When viewing the industry in a narrow scope, it can appear that RP is progressing slowly.

However, from a vantage point that provides a view of the entire market, the level of change and development is exciting and quite spectacular. There are many interesting and powerful developments. Some have been recently announced, others are soon to be commercialized, and the balance is in the developmental phase. These many efforts span the key areas of breakthrough growth, which includes technologies, materials, and applications.

In spite of the past failures of machine vendors in the RP industry, startup operations will continue to enter the market with new and interesting technology. Although the going will be tough, Wohlers Associates believes that several startup companies will succeed in establishing themselves in the RP industry within the next five years. Combined with the demise of established players, these emerging companies will bring the total vendor count to 16, down from 23 in 2000.

To survive, many system manufacturers have broadened their field of vision to include the entire industrial market. Without evaluation, the strategy of gaining a smaller percentage of a bigger market seems reasonable. But many companies have failed by stepping out of a market niche. Specialization is an easier path to success than is generalization.

In the spirit of specialization and niche marketing, new players may find the most success. A new company is unfettered by customer demands and investor expectations. The new players have the opportunity to pick, and even create, the game in which they chose to play. There is also an inherent nimbleness granted to a new organization. Usually, established organizations are unable to quickly change strategies and game plans. New companies do not have to face the difficulties of supporting legacy systems, outdated methods of distribution and support, and shrinking margins.

RP is developing at both ends of the product development spectrum. At the front end, 3D printing for concept modeling is growing impressively. As low-cost systems develop, 3D printers could make it difficult for companies to sell high-end RP systems at high-end prices. At the back end, the technology is evolving from prototyping and tooling to rapid manufacturing. As the idea of RM develops, it will support the movement toward mass customization, where ultimately, a production run will consist of a single part.

The exceptional growth in unit sales of solid modeling software will pull RP forward to greater acceptance. As evidenced in the many examples within *Wohlers Report 2001*, compelling reasons to use the technology have been established. Annual sales, both in units and dollars, continue to increase. Exciting, new technology has the potential to accelerate the growth of the RP industry, creating a vortex into which the pragmatic buyers will be drawn. New users will provide desperately needed revenue to fund R&D and new product developments. With the technological advances, more users will be drawn into RP. The larger population of users will spread development costs, prices will decrease, and even more users of the technology will develop. This cycle feeds upon itself to create tremendous growth.

## Acknowledgments

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@atirapid.com](mailto:ati@atirapid.com) and [www.atirapid.com](http://www.atirapid.com).

The author appreciates the individuals and organizations that contributed to *Wohlers Report 2001*. A very special thank you to Todd Grimm for the countless hours and precious insight that he provided. Thanks to David Tait for teaming with Wohlers Associates to estimate the size of the service provider market. Thanks also to Geoff Smith-Moritz, who contributed to

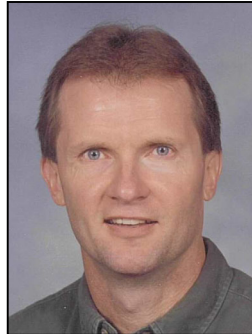


the service market estimate, as well as to other parts of this report. Thanks to Masato Imamura for providing information on Japan. And finally, the author thanks the following individuals for their kind and helpful support.

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## About the author

Industry consultant, analyst, and speaker Terry Wohlers is president of Wohlers Associates, Inc., an independent consulting firm he founded in 1986. For the past 24 years, he has focused his education, research, and practice on design and manufacturing. Terry's views and opinions come from years of collecting and analyzing market data, coupled with work as a consultant and advisor to major organizations in the Americas, Europe, the Middle East, and Asia.



Terry has authored 250 books, articles, reports, and technical papers on engineering and manufacturing automation. He has presented to thousands of engineers and managers and has been a keynote speaker at major industry events around the world. Last year, for example, he presented in France, Germany, Israel, Japan, South Africa, Sweden, United States, and Wales. His appetite for adventure has driven him to climb the Great Wall of China, hike the rain forests of New Zealand, dive among sharks in Belize, bathe in the Dead Sea, and encounter lions and rhinos in Africa.

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. Today, GARPA serves as a catalyst for the exchange 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 \$395, which includes Priority Mail shipping. For orders outside the U.S., the price is \$425, which includes Global Priority Mail shipping.

To order one or more copies, please provide a Visa, MasterCard, or American Express number and expiration date by fax, phone, or e-mail, or send a check in U.S. dollars drawn on a U.S. bank to:

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The report's table of contents and an order form are available at **wohlersassociates.com**. The website also provides access to more than 200 related websites and 80 articles, technical papers, reports, and other documents on rapid prototyping, rapid tooling, 3D printing, CAD/CAM, and reverse engineering. All 80 documents are available to read on-line free of charge.

## Acknowledgments

### About the author

### Focus of this report

### Introduction to rapid prototyping and tooling

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- Installations by country

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PHAST

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- Rapid manufacturing
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### F&S GmbH

### Helisys

### Kinergy

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### Optomec

### ProMetal

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### Sanders Design International

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- Soligen
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3D View

Rapid Prototyping Module

Geomagic Studio

Paraform

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