*Rapid Prototyping & Tooling*

# State of the Industry

*1998 Worldwide Progress Report*

## Executive Summary

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W O H L E R S
A S S O C I A T E S

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## Focus of report

This document provides a sampling of the information published in *Rapid Prototyping & Tooling State of the Industry: 1998 Worldwide Progress Report*. The 204-page report focuses on many facets of rapid prototyping and tooling, including the applications of rapid prototyping, time-to-market issues, industry growth, service bureaus, new approaches to metal tooling, materials, and software for rapid prototyping. The report also reviews system manufacturers in the US, Europe, and Asia, new system developments, R&D programs, trends in CAD solid modeling, 3D printing for concept modeling, medical modeling, reverse engineering, and the future of rapid prototyping. The report includes 28 charts and graphs, 16 tables, and 34 photographs and illustrations.

## Introduction to RP and tooling

*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 model data created from 3D object digitizing systems. Using an additive approach to building shapes, RP systems join liquid, powder, and sheet materials to form physical objects. Layer by layer, RP machines fabricate plastic, wood, ceramic, and metal parts using thin, horizontal cross sections from the computer model.

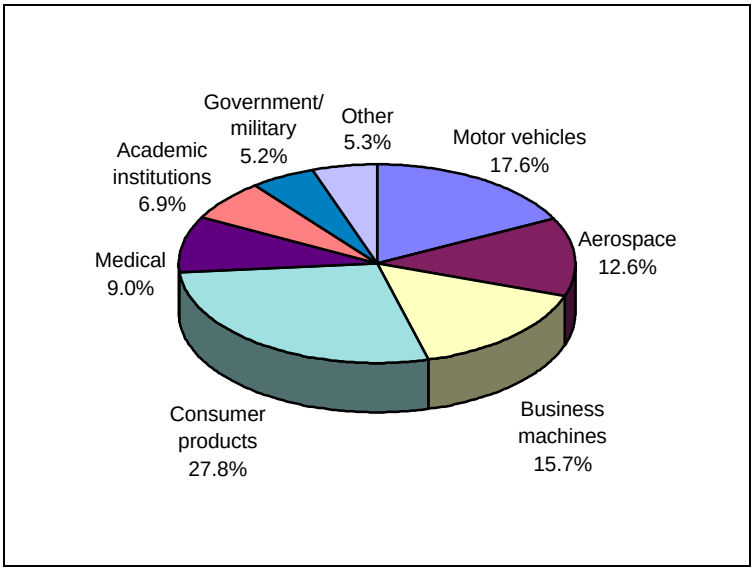
Manufacturing organizations use RP to produce prototypes of injection-molded parts and metal castings that go into everything from copy machines, computers, and cellular phones to automobile instrument panels, airplane subassemblies, and medical diagnostic equipment. Most companies use it to help improve time to market. As a visualization tool, RP helps companies reduce the likelihood of delivering the *wrong* product to market. Some argue that rapid prototyping is a journey, not a destination – a strategy, not a technology.

On the heels of RP is *rapid tooling (RT)*. Most will agree that RT is driven from a digital database – the key to making it rapid. One way to do this is to take advantage of CAD solid modeling and RP. RP-driven RT accelerates the tooling process using RP patterns that are, in turn,

used to produce molds. Another method of RT is to produce core and cavity mold inserts directly from a digital database, using either an additive, layer-by-layer approach or CNC machining.

## Industries being served

In the early days of RP, the automotive and aerospace industries dominated the RP market, accounting for about half of the total market. This is no longer the case as RP has spread into other industries. The following chart shows the industry sectors that are now using RP technology based on data collected by Wohlers Associates.




Source: Wohlers Associates, Inc.

As you can see, consumer products has firmly established itself as the number one market for RP systems. The category named *Other* 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.

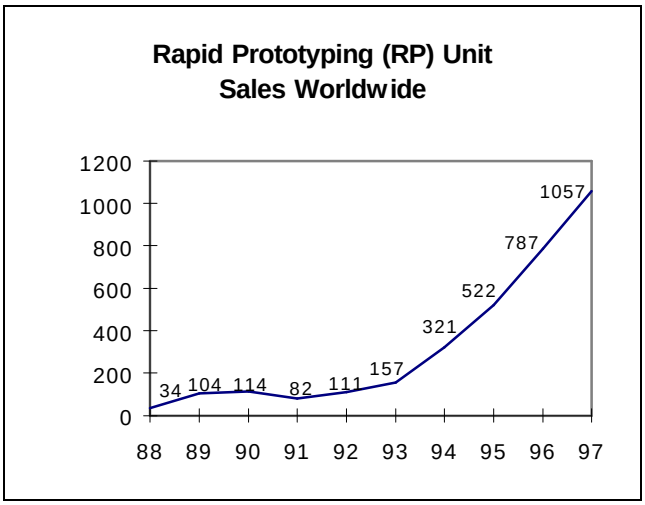
## Market growth

Last year was a good one for some, disappointing for others. Many service bureaus and RP system manufacturers were plagued with financial difficulties. Meanwhile, many regions of the world experienced unprecedented growth. As a whole, revenue growth from RP products and services worldwide were down significantly for the year, although unit sales remained strong.

RP continues to expand into countries that were once slow to embrace the technology. Most notably, organizations in countries such as Canada, Italy, United Kingdom, Hong Kong, Taiwan, India, and Malaysia are buying systems like never before. In the future, expect countries such as Russia, Spain, Finland, Sweden, Brazil, and China to adopt the technology more aggressively than in the past.

The primary RP market worldwide grew by a discouraging 7.5% to an estimated $452.6 million. In 1996, the market grew by 42.6% to $421 million. The *primary* market consists of all products and services directly associated with rapid prototyping. *Products* include RP systems, system upgrades, materials, and after-market products such as third-party software and lasers. *Services* include revenues generated from RP models and patterns produced on RP systems at service bureaus, RP system maintenance contracts, training, seminars, conferences, expositions, advertising, publications, and consulting services.

Last year, an estimated 1,057 RP systems were sold worldwide, the first time annual unit sales exceeded the 1,000-unit mark in RP's 10-year history. At this time last year, Wohlers Associates had forecast sales of 1,070 units for 1997, an estimate that was off by about 1%. Growth for the year was 34.3%, compared to nearly 51% the year before, when 787 systems were sold.




Source: Wohlers Associates, Inc.

Growth in unit sales last year did not decline to the same extent as revenues because the average selling price of an RP system has declined. Through the end of last year, system manufacturers had sold a total of 3,289 RP systems to industrial, academic, and government sites around the world.

## Prices are declining at service bureaus

Several factors are causing prices to drop at service bureaus (SBs). New SBs that have appeared over the past two years have made the biggest impact. As one of the few ways to attract new business, these companies have priced their RP models under the competition. This has caused the competition to lower prices, which in turn has caused the new SBs to reduce prices further. This is a textbook case of supply and demand at work. When the supply increases, demand and prices decline.

SBs are also beginning to lose the market for concept models. Users benefit the most from design visualization tools that offer quick results. Using an SB is faster than hand-crafting a model, but it's not as fast as having an office system sit close to you. As this idea catches on, fewer companies will rely on SBs for concept models.

## Rapid tooling

The list of RT developments continues to grow. Examples are CEMCOM, Dynamic Tooling, ExpressTool, and ExtrudeHone. Each approach comes with a unique set of limitations, yet each promises to reduce the time it takes to produce metal tooling. Except for ExtrudeHone, these companies use a pattern to produce core and cavity mold inserts. None of the ones mentioned here have been fully commercialized, and their developers are somewhat reluctant to say *exactly* how they work.

None of the new RT approaches offer the choice of material, work volume, or accuracy of CNC machining. Furthermore, these new processes may also have difficulty competing on speed as users of CNC streamline and standardize methods of machined tooling. Still, it is interesting to watch these developments unfold, and if one of them becomes a hit, RT could do for tooling what RP has done for prototyping.

## Europe, Japan, and other regions of the world

Few companies in Europe have developed RP technology that have had a commercial impact on the RP industry. This is one reason why some European nations have been slow to accept RP technology. Even so, RP unit sales are growing impressively in many European nations. Installations have been occurring in countries where collaborative projects, consortia, and local and national government programs are in place to help stimulate growth.

Several countries have initiated RP groups and member associations focused on rapid prototyping and tooling. The following provides a list of example RP-related groups and associations that have formed or are in the process of forming. Note that some of the organizations are established entities that have organized a regional or national group.

Australia's Queensland Manufacturing Institute (QMI)
Canada's National Research Council
Chinese Rapid Prototyping and Manufacturing Association
Finnish Rapid Prototyping Association (FiRPA)
French Rapid Prototyping Association (AFPR)
Germany's NC Gesellschaft

Hong Kong Society for Rapid Prototyping and Tooling
Italian Rapid Prototyping Association (APRI)
Japanese Association of Rapid Prototyping Industry (JARI)
South Africa's Time Compression Technologies Siliconworks Centre
Swedish Industrial Network on FFF
UK's Rapid Prototyping and Manufacturing Association (RPMA)
USA's Rapid Prototyping Association of the Society of Manufacturing Engineers

These organizations, groups, and associations have been instrumental in educating people about the realistic benefits of rapid prototyping and tooling methods and technologies.

1997 was a good year for sales in Japan, despite an ongoing weak economy. Overall, unit sales grew by 44%. The year before, sales were flat, after very good growth in 1995. Only 2% of the units sold by Japanese system manufacturers were exported, according to Dr. Masato Imamura, Tokyo Research Center. System manufacturers in Japan expect strong sales in 1998.

It is interesting to compare the commercial offerings in the US with those in Japan. In the US, only two of the eight system manufacturers develop and sell stereolithography. Together, these eight manufacturers represent nine different RP technologies. In Japan, six of the seven manufacturers are developing and selling forms of stereolithography only.

## Other trends

The CAD/CAM/CAE industry is comprised of more than 20 major software vendors, none with more than a 20% market share. In part, this explains why the industry is in a period of consolidation. In the past year, Solidworks Corp. and Deneb were purchased by Catia developer Dassault. In late 1997, Parametric Technology Corp. purchased Computervision, and Intergraph and EDS Unigraphics merged their CAD/CAM businesses. All of this acquisition and merger activity caught a lot of people by surprise, and many wonder what the future might hold for these companies and their products.

The CAM market is incredibly fragmented—worse than the CAD market—with CNC Software (Mastercam) owning 12% of the market

and nine others owning 3 to 7%, according to CIMdata. The remaining 52% of the market is made up of 90 other companies that own 2% or less. If you talk with 10 companies, chances are good that only two, maybe three, will be using the same software. There's no clear winner.

Mike McEvoy, vice president of Baxter Healthcare's Advanced Engineering Design Center, once said, "RP for medical applications is a sleeping giant." He's right. Countless models have been built to demonstrate how the medical profession can take advantage of what RP has to offer. In the US, Europe, and Japan, there have been many documented cases in which surgeons have used RP models to help plan complex surgeries. At the same time, RP has been relatively slow to catch on in the field of medicine, especially in the US.

3D printers are a less costly and less capable variation of RP technology. Both conventional RP and 3D printers build models and prototype parts, so there is inevitable overlap between these two classes of machine technology. As low-cost 3D printing systems improve, they could make it difficult for companies to sell high-end RP systems at high-end prices. This is especially true for applications where rapid visualization is important. When you compare the cost of a 3D printed model to a conventional RP model, the difference can be dramatic.

Interestingly, some people wonder whether the 3D printing market will develop at all. They expect that virtual prototyping (VP) will someday eliminate the need for many physical models and prototype parts. If this holds true, VP could do to 3D printing what 3D printing could do to high-end RP. Already, CAD solid modeling—a basic form of VP—has helped reduce the need for some early physical modeling. As VP tools offer richer working environments and engage other human senses, such as touch, they will surely become a factor. Most will agree that this kind of progress is years into the future.

## Summary

As RP becomes reasonably inexpensive, people will indeed find new and interesting applications for it. Architects will use it to produce proposed building designs, enabling customers to visualize more easily how the final building will look. Sculptors will combine the flexibility of computer modeling with RP to produce exotic shapes. In the field of medicine, surgeons will favor RP models over x-ray images for planning critical operations such as craniofacial surgery.

With CAD solid modeling dipping under the $500 mark, it will be easier for schools to take advantage of low-cost RP to teach important concepts in science, math, industrial technology, manufacturing, engineering, biology, anatomy, medicine, and other subjects. Individuals will take advantage of it at home to experiment with new ideas and inventions that before were not possible.

RP became available when the computer allowed it to. As a result, many companies are benefiting from digitally-driven prototyping and tooling. It all starts at the computer. Organizations that take advantage of 3D computing and RP contribute to the growth and development of RP and benefit from being a part of this exciting and fast-changing industry.

## How to learn more

Visit http://lamar.colostate.edu/~wohlers to see the full report's table of contents. Copies of the report are available from:

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At WohlersAssociates.com, you can access 45 articles, technical papers, reports, and other documents on rapid prototyping, rapid tooling, 3D printing for concept modeling, CAD/CAM, and reverse engineering. This web site also provides links to 140 RP system manufacturers, CAD/CAM vendors, service bureaus, universities, and other organizations focusing on rapid product development. Many use this web site as a starting point for exploring RP products and services worldwide.

A rapid prototyping mail list (rp-ml) is available to anyone with an e-mail address. To join the rp-ml, send an e-mail message to majordomo@ltk.hut.fi. Enter *subscribe rp-ml* in the body of the message. The subject line is ignored. Automatically, you will receive all messages sent to the list. Post questions and comments to rp-ml@ltk.hut.fi. To remove yourself from this list, send mail to majordomo@ltk.hut.fi with *unsubscribe rp-ml* in the body of the message. A mail list archive is updated daily at http://ltk.hut.fi/archives/.

Wohlers Associates, Inc. is an 11-year old independent consulting firm that focuses on new approaches to rapid product development. As the company's principal consultant and president, Terry Wohlers tracks new methods and technologies and works closely with his clients to determine a direction that gives them a strategic edge. As part of this work, he identifies trends, anticipates future developments, and tests advanced approaches to new product design, modeling, prototyping, and tooling.

In 1992, Wohlers led 14 individuals from industry and academia to form the world's 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. Individual membership is available in the RPA/SME, the largest individual member association on the subject. RPA/SME is aimed at enhancing the capabilities of its members and the manufacturing community through interactive education of advanced rapid product development technologies. For more information, contact SME.