

7. The Rapid Prototyping Industry

Overview and a Bit of History

Rapid prototyping, or more precisely additive fabrication technology, has developed steadily as an industry over the past two decades. The manufacturing sector of the industry now comprises approximately sixty commercial companies that exclusively produce products, materials, software and related services for the field, as well as a number of additional companies for which additive fabrication is a segment of their business. The leading six companies in the field had aggregate sales estimated at \$696 million in 2008, representing nearly 60% of the total revenue stream. Overall sales grew 3.7% from \$1.14 billion to \$1.18 billion in 2008 according to Wohlers Report 2009. This total includes revenue from hundreds of service bureaus as well as the manufacturing sector [1]. Nearly 5,100 systems were sold worldwide in 2008 [2].

3D Systems, Inc. pioneered the market with the commercial introduction in 1988 of its first system based on stereolithography technology. 3D Systems remains the market revenue leader, but by 2002 Stratasys, Inc. was selling more than twice as many machines and the company has widened that gap in subsequent years.

Early machines sold for hundreds of thousands of dollars, and even though a careful cost accounting could show tangible savings of many times the purchase price of such systems, it wasn't a trivial exercise. Early adopters were thus for the most part very large companies who could make such a calculation and afford the steep entry price.

In recent years, there has been a strong drive toward much lower-cost systems, often referred to as 3D printers or concept modelers. 3D printers can be located close to engineering groups and other direct users and are easier and friendlier to operate. They provide support for design confirmation applications and can also frequently be used to make adequately functional parts for test and actual use.

As system prices decreased below the \$60,000 level starting in 1996, users found it easier to justify purchasing a rapid prototyping system. At the beginning of 2002, two major US competitors, Stratasys and Z Corporation, introduced machines with selling prices in the \$30,000 range which accelerated this trend and led to considerably higher unit sales. Prices have continued to come down, with recent economic trends providing added impetus. Entry level systems are now available for less than \$10,000, with users offered a choice of technologies. New competitors and the rise of a vibrant open source system community are likely to result in prices being driven below the \$5,000 level in the next year or two.

Many RP systems still sell for hundreds of thousands of dollars, of course. The justification is that these machines either provide greater accuracy, higher speeds or more functional materials than the lower cost 3D printers. This disparity is narrowing with each passing day, however, as vendors improve the performance of their low-cost offerings. A much greater volume of machines lowers manufacturing costs and provides a base for greatly expanding high-margin material sales. The long-term economic model of this segment of the industry is probably not dissimilar to that of the 2D printer market today which is essentially a vehicle for selling ink.

Another major industry trend is the use of additive fabrication technologies to directly manufacture functional, final-use, parts. So-called rapid manufacturing is seeping into a wide range of applications where the ability to fabricate geometrically-complex, or customized or unique parts is important. Making small to moderate volumes of parts with greatly lower, or even zero, tooling costs is a strong driving force for this market segment, as is the direct fabrication of tooling itself.

Fields such as aerospace and medicine have been early adopters and the use of additive fabrication is now routine in some of these applications. This trend can be expected to grow substantially as knowledge of the technology's capabilities becomes more widely known and with ongoing improvements in machinery and materials.

System manufacturers provide a variety of additive fabrication technologies, many of which address distinct market segments. In addition, the earlier large capital and training costs of rapid prototyping systems has fostered the growth of a service bureau industry which provides a broad range of engineering, design, and prototyping services to its customers. There are now more than 900 such service providing locations worldwide.

The remarkable progress made to date, and the large number of innovations being pursued in laboratories all over the world, form a solid foundation for solving an enormous range of problems in the future using additive fabrication.

RP Products and Services

The rapid prototyping market is composed of a mix of systems, materials and services. Systems include the rapid prototyping hardware and its corresponding software. Materials are the consumable substances used in the construction of the part. They are usually specific to the particular form of rapid prototyping technology and are often proprietary. Services include revenue generated by the numerous rapid prototyping service bureau locations in operation worldwide, in addition to maintenance contracts, training, and consulting offered primarily by the system vendors.

Rapid Prototyping Customers

Rapid prototyping systems have been sold to customers in a diverse group of industries. While the business originated in the United States, much user and vendor activity now takes place in Europe and Asia. Major buyers are still found in the automotive, aerospace, consumer electronics and business machine industries which were the earliest adopters. Applications are also found in other segments, such as the toy, jewelry, medical and consumer product industries. Many small to medium size businesses are becoming more involved, however, as the average price of systems drops and the benefits of 3D printing become more widely understood. Indeed, with the advent of affordable systems, a large number of high schools and smaller colleges have been able to acquire systems.

Adoption of 3D CAD (three dimensional computer aided design, also referred to as CAD solid modeling) is a prerequisite to the use of rapid prototyping systems. A three dimensional description of the item to be fabricated is needed. Software pro
analyzes and transforms the 3D CAD design into a
system.

**The rest of the Chapter is Omitted
in this brief sample.**