

EXECUTIVE SUMMARY

# Wohlers Report

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3D Printing and Additive Manufacturing State of the Industry

Annual Worldwide Progress Report





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Unless otherwise noted, Terry Wohlers and Tim Caffrey, both of Wohlers Associates, Inc., authored the sections of this report.

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## Introduction

This executive summary provides a sampling of the information published in *Wohlers Report 2014*, a 276-page study. The publication provides a global review and analysis of the markets, technologies, and applications of additive manufacturing (AM) and 3D printing, terms that are being used interchangeably. This edition marks the 19th consecutive year of the report's publication.

The annual report is written for product development and manufacturing professionals and organizations worldwide. Among the groups that have found it useful in the past are product developers, manufacturers, suppliers, service providers, researchers, educators, analysts, entrepreneurs, and investors.

Additive manufacturing technology is most commonly used for modeling, prototyping, tooling, short-run production, and series production applications. This report covers these and many other applications. It also addresses the challenges that organizations face when attempting to understand and evaluate the many AM materials, systems, and services that are available today, and are expected in the future.

A key part of *Wohlers Report 2014* is its thorough accounting of the AM industry's growth, including revenues and machine unit sales, complete with tables and charts that illustrate relevant trends, history, and industrial segments. It also forecasts future opportunities and growth.

The report addresses many elements of AM, including its history, the mix of applications, and the industries adopting the technology. The report also provides a synopsis of each of the AM system manufacturers, along with important developments from the past 12–18 months. Survey data from system manufacturers and service providers provide a detailed report on both groups. The data from these two groups is important because it serves as a barometer of the industry's health and direction.

The 2014 report provides current information on developments and trends in the production of parts for final products, covering exciting applications of AM for custom, special edition, short-run, and series production parts. Also considered are intellectual property issues that the AM industry must confront as it becomes a more popular method of production.

*Wohlers Report 2014* provides updates on recent developments in Africa, the Asia/Pacific region, Europe, the U.S., and other parts of the world. It tracks the growth of CAD solid modeling, reports on advances in materials used for AM, and presents applications and technologies for 3D scanning and reverse engineering. The report also includes information on post-processing considerations related to additive manufacturing operations.

The final parts of the report cover emerging technologies, government-sponsored research and development, collaborations and consortia, and the activities of 84 academic and 11 research institutes around the world.

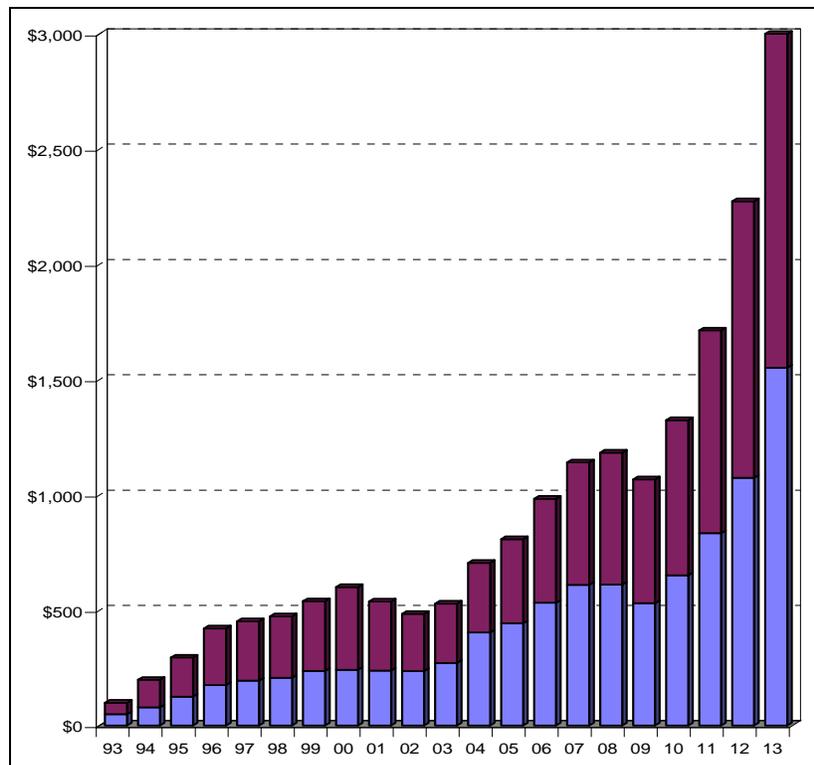
*Wohlers Report 2014* concludes with a discussion of the current trends and future direction of additive manufacturing—what is driving the industry today and what to expect in the years ahead—to assist in strategic planning and investing. To supplement the review and analysis, the report includes 35 charts and graphs, 60 tables, and 248 photographs and illustrations.

## AM surpasses \$3 billion milestone

The additive manufacturing market in 2013, consisting of all AM products and services worldwide, grew 34.9% (CAGR) to \$3.07 billion. This compares to growth in 2012 of 32.7% to \$2.275 billion. Industry-wide growth in 2011 and 2010 was a healthy 29.4% and 24.1%, respectively.

The \$3.07 billion estimate is comprised of revenues generated in the *primary* additive manufacturing market. This segment consists of all products and services directly associated with AM processes worldwide. *Products* include AM systems, system upgrades, materials, and aftermarket products, such as software and lasers. *Services* include revenues generated from parts produced on AM systems by service providers, system maintenance contracts, training, seminars, conferences, expositions, advertising, publications, contract research, and consulting services.

The following chart provides revenues (in millions of dollars) for AM products and services worldwide. As you can see, the past four years are up significantly from previous years, and the market has nearly tripled over this period of time.



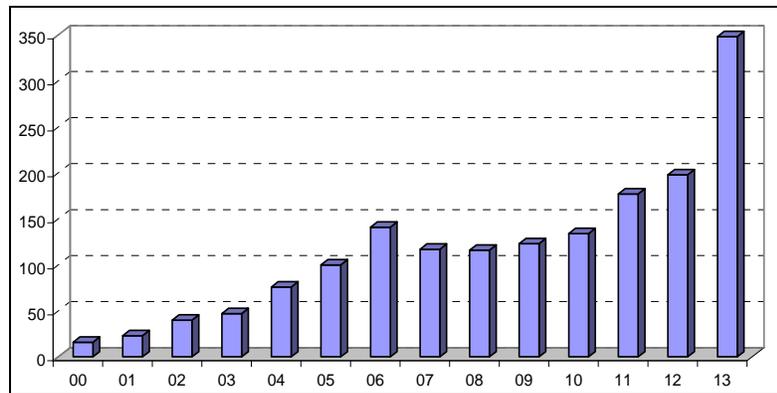
Source: Wohlers Associates, Inc.

The lower (blue) segment of the bars represents products, while the upper (burgundy) segment represents services. Neither category includes secondary processes, such as tooling, molded parts, or castings. The secondary market segment is reported separately.

### Metal AM takes flight

AM systems for metal parts are increasing in popularity, as shown in the following chart. Wohlers Associates has been tracking this market segment for 14 years, but this is only the second time to publish metal-based AM machine unit sales by year in this report. As the chart indicates, 348 of these machines were sold in 2013, compared to 198 in 2012

Metal AM is growing faster than the rest of the AM market. Sales of metal AM systems increased 75.8% in 2013. In some ways, metal AM has come further in 10 years than polymer AM has in 25 years. The current applications for metal AM parts from aerospace and orthopedic implant companies are good examples. Starting in 2015, GE Aviation will use metal AM to manufacture more than 30,000 fuel nozzles annually for its new LEAP engine. More than 90,000 acetabular (hip cup) implants have been produced, and about 40,000 of them have been implanted into patients.



Source: Wohlers Associates, Inc.

Additional opportunities for production metal applications will emerge, so this subset of the industry could possibly grow at a pace that this industry has never seen.

### Worldwide attention

In 2014, interest in 3D printing has reached an unprecedented level. The phenomenal attention began in 2012, and it was relatively sudden. Governments, major corporations, investors, and the mainstream media developed an insatiable appetite for additive manufacturing.

Publicly traded stocks from AM system manufacturers have drawn tremendous interest from the investment community. Most share prices and market capitalizations rose impressively throughout 2013. Corporations and individuals, as well as national, regional, and local governments around the world, are investing in ways that have surprised many.

Most technology-oriented corporations try to anticipate the future in an effort to develop the right products at the right time. After passively observing the AM industry for 25 years, many large corporations are actively developing strategies for the near future.

Crowdfunding sites have turned out to be excellent starting places for 3D printer projects. Two of the top three technology projects of all time at Kickstarter are 3D printers. It has been said that 3D printing “democratizes” manufacturing. Crowdfunding is a way of “democratizing” startup ventures. The two in combination are powerful.

3D printing is helping to invigorate manufacturing. 3D printing elicits a “wow” reaction when people see or learn of it for the first time. To young people, 3D printing is high tech, cutting edge, and cool. In fact, many see it as a way to make interesting objects and do not view it as manufacturing at all. Many schools are installing 3D printers to support their science, technology, engineering, and math programs. In this way, 3D printing can play a role in transforming public perception of manufacturing.

The non-technical public has become enamored with 3D printing. People with little or no manufacturing experience are opening 3D print shops. Everyone knows someone—an acquaintance, a father-in-law, a bus driver—who wants to “get into” 3D printing. For these people, 3D printing symbolizes a bright, technological future. Whether these grand aspirations are justified or not, only time will tell.

## AM’s future

The industry has experienced impressive progress, but it has seen little more than the tip of the iceberg of what is possible. The next big change is the manufacture of parts that go into final products across many industries. This is where serious money is being spent and where most future opportunities in AM will develop.

The industry has experienced dramatic progress over the past two years. Many people believe 3D printing is the next “big thing,” similar to the development of the semiconductor, computer, and Internet. Others believe that the next Apple or Google is waiting in the wings for 3D printing, as investors salivate over the possibility.



3D-printed concept model of an airplane fuselage of the future, courtesy of Airbus

It has been said that it is easy to forecast the future, but very difficult to do it accurately. Methods used by Wohlers Associates to forecast the future include 1) extending trend lines that have developed in recent years, 2) evaluating early technology developments that have reached the proof-of-concept phase, and 3) considering recent and substantial investments being made by corporations, governments, and educational and research institutions. We used these and other methods, coupled with market insight and the opinions of our many contacts, to develop our industry forecasts.

The AM industry is expected to continue strong growth over the next several years. By 2016, Wohlers Associates forecasts the sale of AM products and services to exceed \$7 billion worldwide.

It took the AM industry 20 years to reach \$1 billion in size. In five additional years, the industry generated its second \$1 billion. At \$3.07 billion for 2013, the industry is expected to more than quadruple to about \$12.5 billion by 2018.

Whatever the future holds, Wohlers Associates intends to be there, collecting and processing ideas and data from around the world. We will continue to use our more than 40 years of combined experience to collaborate with the global community, share our unique insights, present our findings, and ultimately, help propel additive manufacturing and 3D printing to the next level.

Terry Wohlers  
Principal Consultant and President

Tim Caffrey  
Senior Consultant

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Industry consultant and analyst Terry Wohlers is president of Wohlers Associates, Inc., an independent consulting firm he founded nearly 28 years ago. Through this company, he has provided consulting assistance to more than 240 organizations in 24 countries.

Wohlers has been cited in countless domestic and foreign publications including *Businessweek*, *CNNMoney*, *The Economist*, *Financial Times*, *Forbes*, *Fortune*, *Inc.*, *Scientific American*, *USA Today*, *The Wall Street Journal*, and

*WIRED*. He has been featured in broadcasts by Bloomberg, CBS Radio News, CNBC, Fox Business, MSNBC, National Public Radio (NPR), Australia's Sky News, Canada's Business News Network (BNN), and China's CCTV News.



In 2007, more than 1,000 industry professionals from around the world selected Wohlers as the #1 most influential person in rapid product development and additive manufacturing by the UK's *TCT* magazine as part of its Top 25 Influential People survey.

Wohlers has authored nearly 400 books, articles, and technical papers on rapid product development and manufacturing. He has given 110 keynote presentations on five continents in cities ranging from New York and Cape Town to Sydney and São Paulo.

His appetite for adventure has motivated him to climb the Great Wall of China, hike the rain forests of New Zealand, dive among sharks in Belize, and bathe in the Dead Sea. He has ridden elephants in Thailand, encountered lions in Africa, explored the ancient pyramids of Egypt, and traveled the crocodile-infested rivers of Malaysian Borneo.

Wohlers received an Honorary Doctoral Degree of Mechanical Engineering from Central University of Technology in Bloemfontein, South Africa in 2004. In 2005, he became a Fellow of the Society of Manufacturing Engineers, a distinction granted to less than 1% of the membership, making it one of the most prestigious honors presented by the Society.



Senior consultant Tim Caffrey holds a bachelor's degree in mechanical engineering from the University of New Mexico. He has worked with Wohlers Associates since 2000. His roles and responsibilities include the execution of consulting projects, speaking, and representing the company at national and international events.

Caffrey's career in additive manufacturing began in 1992 at Boeing's Propulsion Laboratory in Seattle. He directed the company's first in-house AM facility, which grew from one system for wind tunnel models into a large operation with nine systems that provided AM parts throughout the corporation. Starting in 1996, Caffrey managed the AM operation of Plynetics Express in Schaumburg, Illinois, which had, at the time, the largest installed base of AM systems in the world.

His experience includes over 20 years in professional writing and editing, including maintenance procedures for Boeing aircraft and operational tests for Boeing flight testing. It also includes engine case repair procedures at Pratt & Whitney, advertising copywriting at Walmart's corporate headquarters, and personal creative writing projects. He also designed prototype and flight test hardware while at Boeing.

## How to order the report

Go to [wohlersassociates.com](http://wohlersassociates.com) to order the report online. You may also order by phone, fax, or mail. The report, available as a color PDF, is US\$495 worldwide. Credit card payment is preferred.

## ACKNOWLEDGMENTS

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### REALIZER

### RENISHAW

### SLM SOLUTIONS

### SOLIDSCAPE

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### TRUMPF

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### VOXELJET

### OTHER COMPANIES IN ASIA

Aspect

Beijing Longyuan

CMET

D-MEC

Fochif Mechatronics

Hunan Farsoon

InssTek

Keyence

Matsuura

Microjet Technology

Shaanxi Hengtong

Shanghai Union-tech

Trump Precision Machinery

Wuhan Binhu

### OTHER COMPANIES IN EUROPE AND THE U.S.

BeAM

Innovation MediTech

Prodways

DM3D Technology

Sciaky

### EMERGING TECHNOLOGIES

Aeroswift

Arburg Freeformer

Big Area Additive Manufacturing

Digital Metal

DMG Mori Seiki

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America Makes

U.S. government interagency group

Additive Manufacturing Consortium

Direct Manufacturing Research

Center

ASTM International Committee F42

Project TEAM

### U.S. GOVERNMENT-SPONSORED R&D

NSF basic research on existing AM

technology

NSF research on meso, micro, and nano scale technology

National Institutes of Health

Department of Defense

America Makes

### U.S. NATIONAL LABORATORIES

Oak Ridge National Laboratory

Lawrence Livermore National

Laboratory

### GOVERNMENT-SPONSORED R&D IN EUROPE

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