

Wohlers Report 2002



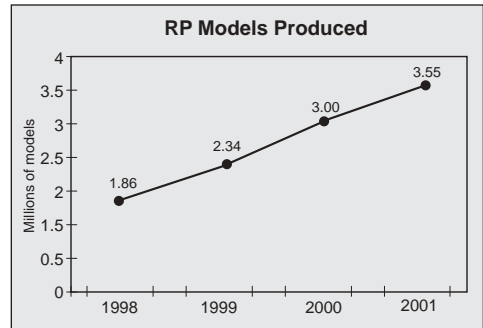
Rapid Prototyping & Tooling State of the Industry

Annual Worldwide Progress Report

TERRY WOHLERS

State of the Industry

Despite a decline in overall industry growth, RP users worldwide produced an estimated 3.55 million models and prototype parts in 2001. This is up 18.3% from the 3 million models produced in 2000. An estimated 2.34 million and 1.86 million parts were produced in 1999 and 1998, respectively.



Source: Wohlers Report 2002

About the Report

This annual market study has established a tradition of offering high-quality analyses that cover all facets of rapid prototyping, including business, product, market, technology, and applications. Forty-nine experts, 47 service providers, 25 system manufacturers, and countless others assisted with its development. The 250-page softbound publication includes 25 charts and graphs, 23 tables, and 87 photographs and illustrations.

"The report has become a virtual 'Bible' of RP ... comprehensive and well organized ... and is highly recommended."

— David Cohn, *Engineering Automation Report*

"Nothing comes close to the authoritative and comprehensive nature of this annually-updated report. It has something for everybody and I highly recommend it."

— Jeffrey Rowe, MCADcafe.com

Table of Contents

Acknowledgments

About the author

Focus of this report

Introduction to rapid prototyping and tooling

PART 1: BACKGROUND

History of RP systems

Industries being served

How RP models are being used

Installations by country

Applications

Communication

Engineering changes

Good ideas and powerful proposals

Concept models

Verifying CAD databases

Styling, ergonomic studies

Functional testing

Prototypes

Metal castings

Early input from suppliers, toolmakers

Quote requests

Rapid tooling

Rapid manufacturing

Unlimited potential

PART 2: INDUSTRY GROWTH

Number of models being produced

Revenue growth

Revenues from products and services

3D Systems dominates

Material sales

Revenues from service providers

Secondary market

Revenues from other services

Unit sales

3D Systems leads

Systems sold by region

Cumulative systems sold by region

Units sold by U.S. manufacturers

Units sold by Japanese manufacturers

Cumulative unit sales by manufacturer

Unit sales by manufacturer and year

3D printer sales by manufacturer and year

Growth trends and sales forecasts

Unit sales growth percentages

Worldwide revenue estimates

Annual revenue growth percentages

Comparing growth of RP and machining markets

Service providers

Growth and location

Mix of machines

Market segment continues to shrink

Number of models produced annually

Investment casting

Working with service providers

Challenging times

What is driving prices downward?

What lies ahead?

PART 3: TOOLING

Advances

Growing list of methods

Thermal management

Risk factors

Indirect approaches

Silicone rubber tooling

Epoxy-based composite tooling

Spray metal tooling

RSP Tooling

Ford's Sprayform

Cast kirksite tooling

RPM (rubber plaster mold) casting

3D Keltool

PolySteel

EcoTool

Swiftool

PHAST

V-Process

Others

Direct approaches

Direct AIM tooling

SLS tooling

DMLS

POM

Others

Other considerations

Machined tooling

Laminate tooling

Hybrid tooling

Space Puzzle Molding

Tool design software

Size of tooling market

Tooling comparison matrix

PART 4: SYSTEM MANUFACTURERS

3D Systems

Materials

SLS business

OptoForm

MJM

Other developments

Arcam

Beijing Yinhua

Cubic Technologies

EOS

EOSINT P 380

20-micron metal powders

Envision Technologies

F&S GmbH

Generis

Kinergy

Objet

QuadraTempo

Support material

Sales underway

Optomec

ProMetal

R4 and R10 products

Recent developments

Sanders Design International

Schroff Development

Solidica

Solidscape

Stratasys

Dimension

Other developments

Z Corp.

Z810

ZCast

Other activities

Others

Helisys

Cubital

Röders

BMT

Aaroflex

Real cost of RP

RP stocks

- Revenues and earnings
- Industry consolidation
- Trends and areas of interest
- Outlook

PART 5: ASIA & EUROPE

Asia

- Hong Kong
- China
- Singapore

Japan

- Unit sales
- Japanese strategy
- CMET, Sony/D-MEC, others
- Acceptance of non-SL technologies
- Sheet lamination systems
- Developments, trends
- Lagging software development
- Accelerated growth expected

Europe

- RAPTIA
- United Kingdom
- Germany
- Italy
- France
- Sweden
- Finland
- Denmark
- The Netherlands
- Belgium

Other regions

- Brazil
- India
- South Africa
- Australia
- Canada
- RP groups and associations

PART 6: RESEARCH & DEVELOPMENT

Developments, patents

3D printers and concept modelers

- Denken Engineering
- Solidimension
- BMT
- Speed Part

Metal and ceramic parts

- AeroMet
- CAM-LEM
- SRI International
- Others

Small parts

- microTEC
- MEMGen
- Mesoscale Integrated Conformal Electronics (MICE)
- Others

Large objects

- Generis
- Others

MIT's 3DP technology

- 3DP process
- Major areas of focus
- ProMetal
- Z Corp.
- Soligen
- Specific Surface
- Therics
- Others

U.S. government-sponsored R&D

NSF funding

DoD funding

DoC funding

RP academic programs

- RP educational activities
- Basic research activities
- Applied research activities
- Future trends and contributions from academia

PART 7: OTHER DEVELOPMENTS

Growth of solid modeling

- Getting good estimates
- Seat and revenue estimates
- Unsaturated market

RP materials

- Stereolithography resins
- Resin business in flux
- Materials for other RP processes
- 3D printers

Medical modeling

- Medical imaging to RP
- Materials for medical RP
- Research
- RP's impact

Reverse engineering

- The technology
- 3D digitizing and scanning
- Data modeling and surface creation
- First article inspection
- Note to the wise

PART 8: WHERE IT'S ALL HEADED

Tough times, bright future

- Economy
- Something is missing
- Necessity is the mother of invention
- Silver lining

Formula for success

- Divergent paths
- 3D printing
- Rapid manufacturing
- What to expect
- Last great barrier
- New rules

Where to learn more

- Internet mail list
- GARPA
- RPA/SME

APPENDICES

Appendix A: Glossary of terms

Appendix B: RP system manufacturers

- United States
- Israel
- Europe
- Japan
- China
- Singapore

Appendix C: Rapid tooling technology developers

- United States
- Europe

Appendix D: RP software companies

Appendix E: Material suppliers

Appendix F: U.S. RP system specifications

Appendix G: RP systems manufactured outside the U.S.

Appendix H: Material properties

Appendix I: 3D digitizing systems

Appendix J: Reverse engineering software

The Author



Industry consultant, analyst, and speaker Terry Wohlers is the principal author of *Wohlers Report 2002*. He has authored more than 250 books, articles, reports, and technical papers on engineering and manufacturing automation. Terry has presented to thousands of engineers and managers and has been a keynote speaker at major industry events around the world.

Development Team

The following individuals and organizations contributed to *Wohlers Report 2002*.

Shreyas Bakshi	Protosys Technologies Private Ltd. (India)
Umberto Baraldi	CRIF (Belgium)
Alain Bernard	University of Nancy I (France)
Nico Blessing	FhG Institute for Mfg. Eng. & Automation (Germany)
Mike Braig	A.G. Edwards & Sons
Tim Caffrey	Caffrey Consulting
Ian Campbell	Loughborough University (England)
Andy Christensen	Medical Modeling LLC
Chua Chee Kai	Nanyang Technological University (Singapore)
Stuart Clyens	Danish Technological Institute (Denmark)
Amba Datt Bhatt	Motilal Nehru Regional Engineering College Allahabad (India)
Deon de Beer	Technikon Free State (South Africa)
Jonas de Carvalho	University of São Paulo - São Carlos (Brazil)
Philip Dickens	Loughborough University (England)
Dimitri Dimitrov	University of Stellenbosch (South Africa)
Thierry Dormal	CRIF (Belgium)
Willie du Preez	CSIR (South Africa)
Frits Feenstra	TNO Institute of Industrial Technology (The Netherlands)
Boris Fritz	Northrop Grumman Corp.
Vito Gervasi	Milwaukee School of Engineering
Ian Gibson	University of Hong Kong (China)
Tim Gornet	University of Louisville
Tom Greaves	New Directions Consulting
Joe Greco	Greco Consulting
Ed Grenda	Castle Island Company
Todd Grimm	Accelerated Technologies, Inc.
Russ Harris	Loughborough University (England)
Berndt Holmer	IVF Industrial Research and Development Corp. (Sweden)
Masato Imamura	Tokyo Research Center (Japan)
Luca Iuliano	Politecnico di Torino (Italy)
Tahar Laoui	University of Leuven (Belgium)
Debbie Leeson	Vantico (South Africa)
Weiyin Ma	City University of Hong Kong (China)
Bent Mieritz	Danish Technological Institute (Denmark)
Bill Mutch	Belcan Corp.
Mike Naylon	Queensland Manufacturing Institute (Australia)
Andy Norwood	Loughborough University (England)
Anshuman Razdan	Arizona State University
Shi Yusheng	Huazhong University of Science and Technology (China)
Michael Siemer	Walt Disney World Company
Geoff Smith-Moritz	CAD/CAM Publishing
Rupert Soar	Loughborough University (England)
Brent Stucker	University of Rhode Island
Dave Tait	LFX Technologies
Jukka Tuomi	Helsinki University of Technology (Finland)
David Wimpenny	University of Warwick (England)
Millan Yeung	National Research Council of Canada (Canada)
Jenny Yu Hoi Jin	University of Hong Kong (China)
Millan Yeung	National Research Council of Canada (Canada)
Shi Yusheng	Huazhong University of Science and Technology (China)

How To Order

Wohlers Report 2002

In the U.S., the report is \$395, which includes Priority Mail shipping. To order one or more copies, send your Visa, MasterCard, or American Express number and expiration date, along with your signature, or send a check for the total amount.

For orders outside the U.S., send your Visa, MasterCard, or American Express number, expiration date, and signature. Payment by credit card is required. The price for orders outside the U.S. is \$425, which includes Global Priority Mail shipping.

If you are not fully satisfied with the report, you will be issued a refund. Phone orders are accepted.

Order Form

Complete the following form and fax or mail it to Wohlers Associates. **Please print clearly.**

Method of Payment

Credit Card (Required for orders outside the U.S.)

Visa MasterCard American Express

Card Number _____

Expiration Date _____

Signature _____

___ Number of copies

Name _____

Company _____

Address _____

City _____

State _____

Postal Code _____

Country _____

Phone _____

Fax _____

E-mail _____



Wohlers Associates, Inc.

OakRidge Business Park • 1511 River Oak Drive

Fort Collins, Colorado 80525 USA

970-225-0086 • Fax 970-225-2027

twohlers@compuserve.com • wohlersassociates.com

Wohlers report 2000: Rapid prototyping&tooling-state of the industry, annual worldwide progress report (Colorado: Wohlers Associates Inc., 2007). DOI: <https://doi.org/10.1080/10667857.1998.11752797>. [4] J.P. Kruth, M.C. Leu, T. Nakagawa: Annals of CIRP, Vol. 47(1998), pp.525-540.Â The scanning strategies were being investigated to potentially achieve a more uniform temporal and spatial distribution of the laser energy, possibly leading to reduced part distortion, by scanning the beam across the sheet surface with both continuous and segmented irradiation geometries. The experimental results revealed that the cross spider scanning strategy could form square and circle sheets into spherical domes.