First recognised patent for SL technology

1986

First commercial RP system available from 3D Systems

1987

1st Issue of Rapid News

All the early RP systems had commercial releases SLA / BPM / SGC / SLS / LOM) / 3DP / FDM

1992

tct celebrates 15 years at the forefront of RPD

Rachel Park

In the beginning...

In the summer of 1992, the first edition of "Rapid News — The Magazine of the Rapid Prototyping and Tooling Industry," was published by the Advanced Technology Centre of the University of Warwick, soon to be Warwick Manufacturing Group (WMG).

The magazine's then Editor, Lee Styger, opened the magazine with his own take on the exciting industry that this magazine was to serve. He wrote of the enthusiasm among the research and academic circles focusing on the emerging rapid prototyping (RP) and rapid tooling (RT) technologies, but beyond the processes themselves he addressed the potential for exploiting these technologies to achieve "tangible cost benefits for manufacturing companies around the world." While the technologies themselves have come a long way since then and the applications for which they are used have developed exponentially and beyond many expectations back in 1992, the reason for adopting them has remained constant — to achieve a "reduction in the time of the product development cycle."

The Evolution of Rapid Technologies

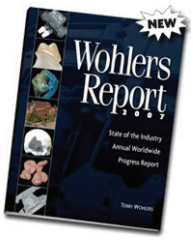
Obviously the magazine's inception was in response to the development and commercialisation of the various rapid prototyping technologies and so the history of rapid prototyping is somewhat older than that of the magazine. The technologies themselves became visible in the late 1980's and researching the actual dates and first technology patents throws up some conflicting information, the conflict arising largely from the fact that some sources quote the dates that the patents were applied for and others quote the dates they were issued — there can be a difference of two or three years here. The first patent application for RP technology was filed by Dr Kodama in Japan in May 1980. Unfortunately for Dr Kodama the full patent specification was subsequently not filed before the one year deadline after the application, which is particularly disastrous considering that he was a patent lawyer! Essentially however, and agreed almost unanimously by the industry, the chronology for rapid prototyping began with the first patent being issued for stereolithography apparatus (SLA) in 1986 to Charles (Chuck) Hull, who went on to co-found 3D Systems later that year. The first commercial system, the SLA-1, was introduced in 1987 and following rigorous testing the first of these systems was sold in 1988 [1].

In 1987, Carl Deckard at the University of Texas, filed a patent for Selective Laser Sintering (SLS) technology, which was issued in 1989 and the technology was later licensed to DTM Inc. 1989 was also the year that Scott Crump, a co-founder of Stratasys Inc. filed a patent for Fused Deposition Modelling (FDM), which was issued in 1992. In Europe, 1989 also saw the creation of EOS GmbH in Germany, founded by Hans Langer. EOS' original foray into RP was with the stereolithography process, however issues with development and commercial demands drove the company towards the plastic sintering process — the company sold its first Stereos system in 1990. The company also started to develop a metal sintering process following work undertaken with a division of Electrolux Finland, which was later acquired by EOS. Other technologies and processes were also being developed at this time, namely Ballistic Particle Manufacturing (BPM) originally patented by William Masters, Laminated Object Manufacturing (LOM) originally patented by Michael Feygin, Solid Ground Curing (SGC) originally patented by Itzchak Pomerantz et al and three dimensional printing (3DP) originally patented by Emanuel Sachs et al.

As a result of these technology developments the early nineties saw a growing number of competing players in the rapid prototyping market — 3D Systems (SLA), BPM Technologies (BPM), Cubital (SGC), DTM (SLS), EOS (SLA and SLS), Helisys (LOM), Soligen (3DP) and Stratasys (FDM).

By 1992 each of these technologies had been driven to commercial release; industrial entrepreneurs, researchers and academics in engineering disciplines had grasped the potential of these processes and were working with the various machines to develop new applications and push the processes to their limits to further advance these embryonic technologies for industrial users. However, then, as now, the issue of materials was a dominant one in the debate regarding the uptake of rapid prototyping. Material developments were, and still prove to be, the key to how far the RP processes can be pushed. The two key players in this field in 1992 were Ciba Geigy (subsequently Vantico and now Huntsman Advanced Materials) and DSM Desotech, which announced its acquisition of Dupont Somos in 1999 and is now DSM Somos. Both of these companies are today still at the forefront of this advanced discipline, together with relatively new organisations that are broadening the competition in terms of advances made, companies such as CRP Technology and Atlas Polymers. Moreover, the RP machine manufacturers themselves have also addressed the materials issue by bringing material development in-house to meet increasing customer demands, most notably Stratasys, EOS and 3D Systems. Beyond this, a number of end users of the machines are also attempting to solve material issues utilising their own R&D, in this respect the materials are not intended for commercial release but rather for their own specific applications. As far as material developments go, to date they have been concerned with broadening the number of different (albeit similar) materials available. As the volumes, and so business opportunities grow, it is believed that there will be far more occurrences of people entering direct competition by offering the same products but competing on price.

The competitive market landscape for RP technology has changed a great deal since 1992. The phenomenal success stories of a number of these companies have been matched by the equally sensational demise of some of the others, together with a typical number of mergers and acquisitions — the most conspicuous being 3D Systems' acquisition of DTM in 2001. For a young industry this is not unexpected, the laws of competition dictate survival of the fittest. However, new and 'improved' technologies were also being delivered to the market throughout the 1990's — Sanders Prototype



First Wohlers Report

1993

1994

Rapid News went mainstream

1995

(later Solidscape) and ZCorporation in 1996, Arcam in 1997 and Objet Geometries in 1998. As the market has grown in maturity there has been a variety of new companies swelling the growing ranks of Western RP companies. It is worth mentioning here that there were many parallel developments in RP also taking place in the Eastern hemisphere, most noticeably in Japan. However, these technologies, while significant in themselves, have not really impacted the global RP market as it exists today.

As in many fledgling sectors, academic and industrial champions of the technologies came together to find the way forward and further develop the potential and the uptake of these processes for manufacturing industry. In academic terms, Phill Dickens, Professor of Manufacturing Technology at Loughborough University (previously of Nottingham and De Montfort universities) is widely recognised both nationally and internationally as the original and most outstanding champion of rapid prototyping technologies. He, together with a team of young, dynamic and enthusiastic researchers and PhD students in this area, really helped put rapid prototyping on the map.

Professor Dickens can recall the origins of his involvement with rapid prototyping, "I remember the first time I was introduced to rapid prototyping in 1990 by Rolf Husemann of Ford in Cologne. Having struggled to make prototypes

in industry it really was a 'Eureka' moment and as a manufacturing engineer the potential was fantastic."

Phill's team really came of age throughout the 1990's and the research group, which over these years included Richard Hague, Phil Reeves, Alan Arthur, Joel Segal, Rupert Soar and Neil Hopkinson amongst others, worked with many top tier industrial organisations and pushed the rapid prototyping technologies to the point where its evolution has seen the advent of rapid manufacturing. As another defining moment in the history of rapid technologies, Professor Dickens also clearly remembers how he arrived at the conclusion that rapid manufacturing was not only feasible it was a reality, "The other key moment for me was when we did some work with Flymo in 1996 and realised that current RP machines could be used economically to replace some injection moulded parts. This led to Rapid Manufacturing."

In terms of championing these rapid technologies on a global scale and raising awareness at every level of industry Terry Wohlers is arguably the single most influential person currently working in this sector. According to Preston Smith, New Product Dynamics (Portland, OR, US), "Terry Wohlers is the spokesperson for the overall rapid prototyping industry. He represents better than anyone else the mainstream prototyping industry." Similar opinions were expressed by innumerable voters for the TCT 25, see page 50. As an industry consultant for more than 20 years and author of the respected Wohlers Report since 1993, Terry's origins in consulting were in computer-aided design (CAD) software. A reflection perhaps of the industry he now represents. The history of CAD, and specifically 3D CAD, follows a similar path to that of RP, only a decade or so earlier. It is no coincidence that the genesis of rapid prototyping came about as the CAD market started to develop and mature, although in the late 1980's the 3D CAD packages available were no where near as sophisticated as those on the market today. Rapid Prototyping demands the use of 3D digital information from which to build the parts and in many ways these two industries have developed simultaneously, each driving new and improved developments for the other. According to Professor Dickens, who was teaching CAD at Nottingham in the late 1980's, "Before Rapid Prototyping came along there was no great need for CAD apart from for CNC programming. Usually, objects would be designed in 2D (often on paper) and if it was to be CNC machined then it was passed over to a CAD-jockey to convert the 2D drawing to a surface model. These surfaces were usually 'lashed together' with mismatching edges, overlapping edges duplicate surfaces and so on. They did not need to have perfect matching edges because the CNC machines were not susceptible to these 'minor' CAD errors. However, when SLA came along it could not cope with these poor surface models — solid models or good surface models became vital. This then further pushed the development of 3D CAD." The advancess made in both industries have been prolific and have changed the nature of product design and development beyond all recognition.

The RP vendor community today is actually diversifying and typically going one of two ways. First there are the companies that are predominantly focused on the high end, still relatively expensive, machines that are gearing up more and more towards part production — rapid manufacturing. The leading companies in this field are working relentlessly to push the boundaries of rapid manufacturing but interestingly enough some are also defining their own terminology for it — Stratasys, which has further developed its FDM process for 'Direct Digital Manufacturing' and EOS, which has developed its sintering process for both plastic and metal parts has embraced the term e-Manufacturing, together with Arcam's EBM technology and MCP's SLM process. In contrast there are the machine manufacturers that are developing and advancing the 'concept modellers' — machines that keep the focus on improving concept development and the prototyping stages of new product development. Companies forging the way ahead here are ZCorporation, with an emphasis on colour prototypes that can be produced in an office environment; Objet Geometries, a company that again offers office-friendly RP machines and develops a wide range of RP materials; EnvisionTec, with its 'end-user-friendly and cost effective desktop system'; and The Dimension 3D Printing Group, which Stratasys has set up as a completely separate division to focus on this specific area of concept modelling whilst it maintains its focus on the FDM technology. And then there is 3D Systems, which defines itself as 'a provider of 3D Modelling, Prototyping and Manufacturing solutions'. As well as the much debated issues of speed and accuracy, the concept modelling market is now fighting a war based on price of the machines. Indeed, 3D Systems recently announced its first concept modeller, due for commercial release this summer, will be available for under $10,000. This sort of price tag would have been unthinkable 15 years ago. Another new low cost addition to the

1st TCT Conference and Exhibition

Rapid News became Time-Compression Technologies Magazine

Formation of GARPA

1996

1998

market that will allegedly hit this year or early in 2008 is Desktop Factory, this concept modeller is reportedly going to be retailing under $5,000.

The Evolution of The TCT Magazine

The WMG's research and promotion of rapid prototyping in the UK was gathering momentum and in 1995 this culminated in a centre feature area at Manufacturing Week. During the show, two young publishers — Christopher Young and Mark Blezard — approached Lee Styger and said they had carried out extensive research and were thinking of starting a magazine for this sector and what did he think. As he offered them a copy of the latest 'Rapid News' he intimated that it already existed, albeit as an association publication, but that the WMG was looking for a media partner for Rapid News to extend its reach and appeal to a much larger audience. The rest, as they say, is history. With the new partnership in place, the magazine benefited from greater perspective. There was no doubting the impact of RP&T on the manufacturing sector or the importance of these technologies for reducing product development time, but this was just one element of a much broader process. To increase the magazine's reach and readership base it expanded its remit to incorporate all of the different facets of product development and now started to offer the readers — the main demographic being design engineers and their management chain — with the necessary information to link these disciplines together holistically in order to really benefit in a significant way. "Concurrent Engineering" and "Simultaneous Engineering" were the mantras that were now expounded and this included:

- Concept Development
- 3D CAD
- Analysis Software
- Rapid Prototyping
- Rapid Tooling
- Manufacturing
- Material Choices/Selection
- Process Management.

At this time the circulation of the magazine grew significantly. In addition to serving the International Rapid Prototyping Association (IRPA) [previously the RP&T Club] the magazine now extended its reach throughout Europe, with in excess of 12,000 subscribers.

In 1996 the market response to the title was phenomenal, similarly the readership base was growing rapidly. However, the market was more segmented and was no where near as "global" as it is today. Developments and uptake in the US were taking place at a faster pace than they were in Europe and the publishers of Rapid News saw the potential of utilising their expertise and launching a US focused edition of Rapid News while maintaining their leading title in Europe. To do this they needed more manpower — 'woman-power' actually. This was when I joined the team. Having worked in the relatively simple (and dare I say it, boring) sector of Medical Device and Pharmaceutical publishing, it was immediately obvious to me that I was now confronted with something very different. This was a dynamic and vibrant industry, where the people I was talking to were not only keen to share their views — they were excited about the possibilities of the technologies they were developing and intent on driving them, and the industry as a whole, forward. Eleven years later, my knowledge base has grown considerably — and continues to do so due to the fast pace of progress in rapid product development.

The very nature of this industry places it at the cutting edge of technological developments for manufacturing, and as a result the first manufacturing companies likely to adopt such technologies are those that are forward thinking, and let's face it, those with the budgets to spend on unproved technology with potential. This is constantly reflected in the magazine but with a view to illustrating that the technologies can be proved and can work for anyone. One of the first articles I worked on was "CFD in the Time-Compression Process: An Interview with Benetton Formula 1." [2] From that day to this, the significance of talking to and working with some of the most prestigious companies in the world — in Formula 1, aerospace, automotive and consumer products, to name a few — to present the message of rapid product development, still gets me excited. In many respects, I have grown up in this industry, and the contacts that I have made and the relationships formed have been long lasting — like me, many of the people that I was talking to eleven years ago as a novice are still around today and are still working relentlessly to keep driving the technologies forward. A number of these people, due to their vast knowledge and undisputed experience are members of the magazine's Editorial Advisory Board — take a look at page 3 of the magazine!

Continued evolution of the magazine's content ensured that it embraced all of the different and newly emerging technologies that could truly aid rapid product development. As a result, the publishers believed that this needed to be reflected in the magazine's name and design. While the origins of the magazine would always be in the "Rapid" technologies, it was important at this time, as it is now, to refute the perception that this was the only topic that the magazine covered. In January 1998 Rapid News became Time-Compression Technologies.

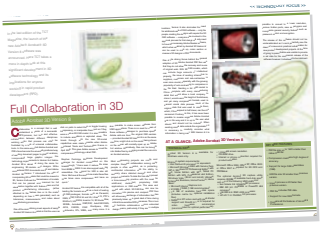
The magazine, together with the renowned annual conference and exhibition, has continued to build on its early success and remains the first title to report the latest developments in this fast moving sector. The most recent 're-branding' has seen the magazine evolve further to reflect the industry's growth and dynamics and at the beginning of 2006 Time-Compression Technologies became The TCT Magazine — a global magazine for anyone involved in rapid product development.

As the industry grows and evolves still further, The TCT Magazine continues to reflect these new and exciting changes, providing the readership with the most up-to-date information available on new product launches, technological developments and, most importantly of all, how these products and technologies can be applied in the manufacturing sector. The industry itself also recognises the remit and the reach of the TCT Magazine, as leading players choose to launch their latest RPD&M products through the magazine pages and/or at the annual TCT exhibition. InnovMetric, EOS, Arcam and The Dimension 3D Printing Group have all selected the TCT Magazine as the medium by which to do just this in the last twelve months alone.

The last couple of years have also seen a complete overhaul of the content and design of the magazine, with the gradual introduction of dedicated sections and columns for the spectrum of disciplines that come under the TCT umbrella, as well as offering a voice to some of the leading associations that work with and support the TCT Magazine in its goals —

Time-Compression Technolgies became the TCT Magazine

1st TCT Conference dedicated to RM applications



2006

2007 and beyond...

organisations such as the RPMA, GARPA and the RM Platform, to name a few. These sections complement the ever present and highly respected feature articles, written by independent experts and users of the technologies.

Looking Ahead ...

This 15 year milestone for the TCT Magazine has provided a timely opportunity to reflect on the developments that have taken place over the last decade and a half. At this precise time in 'Rapid' history it is hard not to draw parallels between the early excitement and vitality that existed as the RP process came into their own and began to be taken seriously with the current 'buzz' that exists around the emergence of RM.

It still amazes me how quickly people start to introduce the phrase "traditional RP" once they grasp the concept of RM. The problem — and the reason I still have a job — is that the number of people grasping the concept of both RP and RM (together with the associated technologies of 3D CAD and simulation software) is still a significant minority. The message is far more widespread than it was in 1992, but even a liberal estimation would be hard pressed to suggest that we are close to half way there. That is why the TCT Magazine will continue to search out the latest developments and applications and continue to spread the word.

However, looking ahead, there are still many exciting things to come. My personal predictions for the next 15 years (in broad brush strokes) are that RM practices will become fairly common place, specifically for low volume high value products as materials are made available to fulfil these applications and the processes are refined further. People will start to refer to "traditional RM" as micro and nano technologies emerge as the next frontier for the manufacturing sector to break through.

Whichever way it goes, the TCT Magazine will be watching and will report it to you first.

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1. Grimm, Todd; *'User's Guide to Rapid Prototyping'*, Chpt 2, 'History of RP', ISBN: 0872636976.
2. Laight, Matthew; *"CFD in the Time Compression Process: An Interview with Benetton Formula 1"*, Rapid News Volume 4, Number 3, pp. 16.