This paper will examine the hybrid practice of integrating computer aided design and/or manufacture with the traditional techniques of metalwork and jewellery. It will explore how digital technology provides not only technical precision—but also crucially an original theatre for creative stimulus extending the boundaries and rejuvenating the traditional vocabulary of the craft.

This will be illustrated with work that although digitally created or inspired nevertheless relies on the integration and knowledge of applying traditional hand skills. The work of Contemporary metalwork and jewellery makers who initiate this hybrid practice will be contacted to contribute to this paper, and will include:-

- Stephen Bottomley (UK) - Digital designed jewellery
- Peter Musson (UK)- CAD Silverware
- David Goodwin (UK) – STL formed jewellery
- Joe Wood (USA- Mass Art) – RP resin cast jewellery

Metalwork and jewellery has the capability to reflect both traditional approaches to the craft as well as the prevailing zeitgeist of the time. The gold and silversmith has been accustomed to holding a pivotal role bridging both science and art. The choice of many contemporary makers to work with new and emerging technologies is therefore not specific to our time - but traditional to our craft. For some it is not only a matter of choice - it is also a challenge, which proves impossible to resist. It is important not to try to imitate craft process with the emerging technology but to extend that craft language and allow the creative freedom it can engender.

The ways in which Computer Aided Design and Manufacture (CAD/CAM) affects the process of creating an artefact compared to the more traditional studio design processes that builds on known hand-craft will be examined. An argument is often made that working with tools capable of such precise repetition leads to the creation of objects that are rendered sterile due to their unnatural perfection. Is this is at odds with the philosophy of a craft discipline that strives for perfection through a precision of making? It seems the potential for CAD/CAM provides to achieve perfection is not only a factor in the choice to use it - but also in the mistrust it engenders.

The programme designers who streamline their software packages in order to present simpler systems for creating digital designs for jewellers, for example, that may then be outputted to the growing range of computer aided manufacture devices, are ironically narrowing the new vocabulary. Thinking out of the box, (or the monitor), is vital for creativity when encountering new technology – just as it is the workshop when experimenting with new processes. The importance of pushing the limits of available software and how the diverse range of programmes available are utilised will be studied.

The virtual world can provide the fresh perspectives in order to stimulate and revitalise older traditional skills. As Paul Derrez, the owner of Gallery RA has said, “New technology can be used for new ideas and old technology can be used for new ideas” (note).
In the late 20th into the 21st Centuries the computer has provided the designer and maker with not only new ways of seeing the world but also with new ways of fashioning it. Digital tooling allows us to examine form and structure from the macro to micro, from impossible viewpoints and within weightless environments. The objects designed with these tools can be sent digitally over any distance to be manufactured in an ever-increasing range of materials in distant cities, or, re-worked between remote designers at conference. Ideas evolve from the conceptual to the virtual, then into the physical and the real.

In 1996 a question asked by Malcolm McCullough in his seminal book 'Abstracting Craft' was "What are the implications for art and craft as atoms become replaced by digital signals and the physicality of reproduction becomes a 'virtual' on screen experience?" 1. For many years this question lay at the heart of the computer aided design / manufacture (CAD/CAM) versus craft debate. Pros and cons were debated; the lack of physically, the loss of tactile contact, new freedoms of design methodology, versatility of material output and increased speed to manufacture. This formed the basis for two years of my research from 1999-2001 at the Royal College of Art; years that I like to think had a symbolism in spanning the 20th and 21st Centuries and a new digital Post-Industrial revolution.

Here and now in 2004 any technological/craft debate is history. The technology is readily available and being used by an ever-growing numbers of designers and especially the new emerging makers. Pandora's Laptop has been opened and that particular digital genie is out of the bag. We are now in a more fortunate position of being able to examine more clearly how CAD/CAM is being used and reflect a little on the new hybrid practice.

STEPHEN BOTTOMLEY

Fig 1

As digital technology enabled the new fabrication of objects it challenged the values traditionally associated with craft -labour, material and intricacy. Rapid prototyping, (RP) turns intangible digital data into physical objects, the virtual to the real, a magical process and in hours rather than the weeks it would have traditionally take by hand techniques. Micro-Drop Fabrication, Stereo lithography, Selective Layer Sintering, Laminated Object Manufacture and Fused Deposition Modelling, all offer an alternative to making objects to the long and laborious hand process's that have become synonymous with craft. Computer Aided Design and Manufacture (CAD/CAM) provided a radically different process for creating objects compared to the more traditional studio design processes that built on known hand skills. CAD/CAM offers far more interesting propositions to a designer and maker than simply increasing speed and reducing labour. It also offers the opportunity to thoroughly explore and manipulate form from all angles and viewpoints and the ability to make radical alterations to scale and shape.
These Orbit rings illustrate a body of work made in 2001 utilising the potential of this technology to rescale the digital designs in order to resize the rings to individual proportions. The digital design for these rings made with Form-Z can be re-scaled within this package or at the rapid prototyping machine itself within the machine's own software to create any range of sizes as individual master wax models. With a closed ring this would normally necessitate a range of size rings being printed by the 3-D wax RP printer to suit all the rings sizes. What I chose to do with these rings was to build into the design the ability to adjust the rings size by hand as an option. So, the rings are spirals that are not closed and can be easily stretched open or closed a size or more. Hand skill and design can often be faster than involving a machine.

As Tanya Harrod has pointed out "objects, like certain examples of silversmithing by Michael Rowe, can look CAD designed when they are not. They simply have a CAD aura". The 'aura' referred to is the geometric form, a structure shared with mathematics and three-dimensional CAD programmes. It is a precise form that has become synonymous with computer design, but as Michael Rowe has commented, is not its sole provenance.

The application of a computer's control and aesthetic restraint is crucial to the work I transcribe from CAD design to low relief metalwork. The role of a computer is not vital to the generation of this work- but it is the appropriate device to achieve the aesthetic quality sought. While these pieces of work speak directly of directing CAD towards remote modelling by CAM the route that brought me into applying computer technology within my work had been centred preliminary on the application of image, texture and pattern.

These pieces of jewellery from 1998 explored the transformation that occurred not only to image, but it's context, identity or meaning but the qualities of pattern that could be derived from that process on to the material through the transcription from digital image to metal surface.

The necessity for the computer can be overstated. These pieces were not dependent on CAD but that process enabled me to achieve it more effectively and was the most appropriate tool to use. As David Watkins has said "Computers have been from time to time important to my work. The challenge of their rationality and their capacity to carry out fascinating but in some respects tedious tasks has often made for a good 'fit' with my immediate aesthetic objectives. I am not however drawn to the use of computers for their own sake. If I don't have the overriding need to get the work done that way, I don't have the patience."
Fig 9

I have designed work with purely the computer in mind. 2001 is a range of pieces in celebration of the present: the here and now. 2001 is also a date of special significance lying at the dawn of a new millennium and already synonymous with the famous Stanley Kubrick / Arthur C Clarke film, 2001 a space odyssey. The form is a classic möbius strip, a familiar mathematical conundrum, or space oddity. The shape is representative of the twisted concept of time and space. A straight strip can represent a journey with a definite end, but by twisting this strip and joining its ends together a journey along its edge will last for infinity. The form was digitally modelled using the design programme 'FormZ' and the text was wrapped around its surface thanks to the innovative reverse engineering software of Delcam CopyCAD.

Fig 10

The model was then rapid prototyped by 3D-Systems growing the model by stereo lithography in a vat of photo reactive resin, hardening the cut layers of the digital design by laser, layer on layer, in a SLA-35000 machine.

Fig 11

In January 2002 eight jewellers from the Association of Contemporary Jewellery responded to a question posed to them in their newsletter, the question was, "What do you seek to make perfect, and what are you happy to leave imperfect in your work?" The overall conclusion expressed by the majority of jewellers was that no avoidable imperfections should be left on a piece of work, yet the quality of handcraft or the marks of the human hand as Giovanni Corvaja put it, should be not be erased. The fear then is that working with tools capable of such precise repetition will lead to the creation of objects that are rendered sterile due to their unnatural perfection. It is a fine line that has to be walked between the aspect of our craft philosophy that strives for perfection and the side that celebrates occasional marks of intelligent intentional interaction. It seems the potential CAD/CAM provides to achieve perfection is not only a factor in the choice to use it - but also in the mistrust it engenders.

A young contemporary designer who walks that line with style is David Goodwin.

DAVID GOODWIN

I would not have been able to visualise my ideas as clearly as I have done if I was not working within a 3D environment. Designing on paper did not convey the quantity and clarity of information that working with 3D modelling could. I still sketched out initial ideas on paper but the final design decisions were made within the 3D world. The ability to see designs in their entirety allowed for greater selective decision-making. Rendering a 3D model in a programme called Flamingo Raytrace produces a photo like image of a possible physical object. Producing a large quantity of designs, I could lay the photo like images out separately and make the decision of which designs to manufacture.

These objects designed within Rhinoceros 3D CAD software are a small selection of dyed polymer resin rings created on the 3D systems viper.

Fig 12-17
There are certain restrictions that are important to notice when designing. All objects must be considered solid, Rhinoceros is predominately a surface program but ensuring that all surfaces are joined therefore creating a closed polysurface allowed all of Grid Ring series to be produced.

These standard polymer resin prototypes are fragile due to the fine geometries. The designs lend themselves to being produced in metal.
The challenge was to use the techniques discussed to create a piece to be fabricated in metal. The pipe command was troublesome as it did not like to generate surfaces on harsh angles over 90 degrees. This led to the designing of more rounded objects which would work with the programme and its functions, hence the design of the ‘Ball Mesh Ring’. It is good to have some boundaries to design within.

I generated two spheres that I then cut with cutting planes to then use the blend surface command to create a surface between the two cut spheres.

The next stage is to contour the object; I used a spacing of 1.5mm between each contour line. The polysurface is then hidden to show the entirety of the curves, the curves are then piped. In this instance I have used a 0.3mm radius for each pipe. This can be varied on each pipe and the pipe can be given an end and start thickness if it is not a closed curve. The surface that is built upon the curve is uniform thickness throughout unless otherwise instructed.

The pipes are mirrored using the mirror command then the original base polysurface is un-hidden. A cylinder is generated to bullion difference a hole through the model to create a finger hole. The cylinder is bullion differentiated then the pipes are hidden to allow work on the original base polysurface.

Curves from the edge of the ring hole are extracted using the duplicate edge command and if they are extracted as broken curves they are then joined together. The polysurface is then deleted. These curves are then piped at a 0.6mm radius. Due to the angle that the mesh pipes were cut at in the bullion difference command they leave a large surface area visible that is covered by the ring pipes being of double thickness.

The pipes are then re-shown to reveal the ball mesh ring in its entirety as shown below in the shaded view port screenshot.

In the rendering I have tried to show how the ring would look in a physical sense if it were 18ct gold.
Fig 32

The 'Ball ring' rendered in Flamingo Raytrace and given a plain gold surface.

Fig 33

Weston Beamor was the company that succeeded where others shied away, in casting the ring using high-pressure vacuum casting equipment after printing the design in a special resin that burnt out cleanly. Below are images of the Ball Mesh Ring straight from the casting.

Fig 34

Fig 35

JOE WOOD

Joe Wood often combines string geometric form with contrasting organic qualities of texture or form. He began combining CAD in his working practice in 1988 as a sketchbook resource and it wasn't until 1998 that he started to use the 3D modelling program Form-Z, to directly model objects for RP. CAD work gave him a new environment to investigate his fascination with sculptural form and ornament, often inspired by architectural references.
Joe Wood, Chairperson of 3D fine Arts at Massachusetts College of Art, uses 3 dimensional modelling software that creates rendered screen images. He also uses the rapid prototyping technique to produce a hard copy of a 3D model which he then colours and adds silver components, to produce a finished jewellery object.

Fig 36

The set of five “Ball Rings” (figure 5) by Joe Wood were computer modelled, rapid prototyped then cast. Joe Wood states that much of his work stems from a continuing interest in the rich tradition of jewellery and object making in metal. Most pieces have been influenced and inspired by studio practices, history, psychology and the philosophies that lay behind significant traditional and contemporary work.

Taking initial design concepts from paper Wood plays with his ideas and works out technical problems on the computer. He tries to create organic shapes from a machine that predominantly conjure up images of hard lines and man-made qualities. This is a common method of working with the computer, using it as a design tool to work out how objects are put together. It would be interesting to see how a computer could be used a separate medium in its own right, something that Wood achieves to a certain degree.

Slowly other craftspeople and the craft industry are seeing the advantages of using computers and it may not be long before craft catches up with design disciplines such as Design Product and Architecture, disciplines that employ the use of computers and 3D design software on a daily basis.

Based in Boston, as the jewellery course leader of Massachusetts College of Art, Wood dealt with a local RP company, Z-Corps, founded from research at neighbouring MIT into RP layer manufacture. The first pieces he made were in 1999 and illustrate a new direction for his work inspired directly from the combined qualities of the modelling capabilities of Form-Z with its strong Nurbs modelling capability and the material quality of the unique resins printed by the Z-corps Z402 3D printer. The titles of Woods work reflect the direct influences of the techniques he utilises as well as the materials he now works with. “When material is integrated into an application”, he explains, “It connects the object to the world. It becomes an object that is a material that is an object.”

Fig 37

Peter Musson

Peter Musson graduated the RCA in 2004. His silverware aims also to interweave new technologies with traditional craft working techniques. Through CNC machining he develops ideas rapidly that will lead to developing new forms which are not possible by only traditional techniques.

He uses the milling machine as an aid for applications such as model making, rapid tooling, for traditional raising stakes and press-forming tools. As in the piece ‘Water Pitcher’ he uses it to make production models for electroforming and casting.
He states, "Within my design I use the language of mass production, at the same time I aim to give my objects a more human quality through imparting individual touches upon them. I use industrial methods of production yet distort the perfect form to give the objects individuality; I achieve this by using craftsmanship ideals which I believe create an emotional connection to the user through the object."
Conclusion

The hybrid practice resulting from integrating computer aided design and/or manufacture with the traditional techniques of metalwork and jewellery reflects concerns that are founded in both traditional approaches to the craft as well as contemporary issues of the time.

The gold and silversmith has been accustomed to holding a pivotal role bridging science, technology and art. The choice of many contemporary makers to work with new and emerging technologies is not specific to our time - but a tradition to our craft. It is not only a matter of choice - it is also a challenge, which proves impossible to resist.

The programme designers who streamline their software packages in order to present simpler systems for creating digital designs for jewellers to be outputted to the growing range of computer aided manufacture devices narrow the new vocabulary. The technological choice and variety offered by different modelling systems provides a range of important triggers to the designer. It is evident from the work we have seen that ideas have been developed by moving back and forth between a range of visual and tactile stimuli. Within the designing CAD stage Tanya Harrod has referred to this as "artist's, applied or otherwise, wisely, wilfully, tend to do low-tech things with high technology. They operate as outsiders with something of a hacker mentality". Thinking out of the packaging box, or ultimately the monitor, is as vital in the creative process when encountering new technology as it is to experimenting with the traditional techniques. The area where these technologies, traditional and contemporary cross over is fertile territory indeed - even if at first, as with David Goodwin's vacuum cast gold Ball ring, they may seem impossible to integrate.

To return again to the question posed by the Association of Contemporary Jewellery I'll share the shortest response with you, the pragmatic response by the Dutch director of Gallerie RA, Paul Derrez that he sent by text, "New technology can be used for new ideas and old technology can be used for new ideas. My experience as a gallery owner is that in general old technology is used for new ideas and that is fine to me".

If indeed the digital revolution is over and the technology is no longer something new but now something old, this is a situation that is unlikely to change - indeed one day it may be considered a traditional craft in its own right.
Footnotes


Stephen Bottomley
Sheffield Hallam University, UK

David Goodwin
Royal College of Art, UK

Something Old/Something New:
The Marriage of Digital - Craft

Fig 1
Orbit Ring
CAD drawing
Form-z 2001 - Stephen Bottomley

Fig 2
Orbit Rings
Sterling silver 2001 - Stephen Bottomley

Fig 3
Orbit Ring #5
Sterling Silver 2001 - Stephen Bottomley

Fig 4
Conditions for Ornament No.6, 1998 - Michael Rowe
Stephen Bottomley  
Sheffield Hallam University, UK

David Goodwin  
Royal College of Art, UK

Something Old/Something New:  
The Marriage of Digital - Craft

**Fig 5**  
Large Ruff, Sterling Silver 1988 - Stephen Bottomley

**Fig 6**  
Blown Glass pendant, Sterling Silver 1998 - Stephen Bottomley

**Fig 7**  
Frame Brooch & 5 interchangeable panels - 18 carat red gold and silver

**Fig 8**  
Two Frame Brooches, 18 carat red gold and silver 1998
Stephen Bottomley  
Sheffield Hallam University, UK  

David Goodwin  
Royal College of Art, UK  

Something Old/Something New:  
The Marriage of Digital - Craft  

**Fig 9**  
2001 Bangle.  
CopyCad digital rendering of model.  
Stephen Bottomley  

**Fig 10**  
2001 Bangles & medals.  
Stephen Bottomley  

**Fig 11**  
SLA Selective Laser Apparatus or Stereo-Lithography Apparatus
Stephen Bottomley  
Sheffield Hallam University, UK

David Goodwin  
Royal College of Art, UK

**Something Old/Something New:**  
The Marriage of Digital - Craft

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**Fig 12**  
Grid Rings 1

**Fig 13**  
Grid Rings 2

**Fig 14**  
Grid Rings 3

**Fig 15**  
Grid Rings 4

**Fig 16**  
Grid Rings 5

**Fig 17**  
Grid Rings 6
Stephen Bottomley  
Sheffield Hallam University, UK

David Goodwin  
Royal College of Art, UK

Something Old/Something New:  
The Marriage of Digital - Craft

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**Fig 18**  
*Ball Mesh Ring - Polymer Resin - David Goodwin. Photo Nick Jell*
Stephen Bottomley  
Sheffield Hallam University, UK  

David Goodwin  
Royal College of Art, UK

Something Old/Something New:  
The Marriage of Digital - Craft

Fig 19  
Creating the base shape to work on - CAD Drawing  
David Goodwin

Fig 20  
Cutting the spheres with cutting planes - CAD Drawing  
David Goodwin

Fig 21  
The two spheres cut open - CAD Drawing  
David Goodwin

Fig 22  
Blended surface between cut spheres - CAD Drawing  
David Goodwin

Fig 23  
Contouring the base shape - CAD Drawing  
David Goodwin

Fig 24  
Piping the contour curves - CAD Drawing  
David Goodwin
Stephen Bottomley  
Sheffield Hallam University, UK  

David Goodwin  
Royal College of Art, UK  

Something Old/Something New:  
The Marriage of Digital - Craft  

Fig 25  
Mirroring the pipes - CAD Drawing  
David Goodwin  

Fig 26  
Cylinder to create finger hole - CAD Drawing  
David Goodwin  

Fig 27  
Cylinder bullion differenced- CAD Drawing  
David Goodwin  

Fig 28  
Working in base shape- CAD Drawing  
David Goodwin
**Fig 29**
*Duplicating Edges on finger hole- CAD Drawing*
David Goodwin

**Fig 30**
*Piping curves at 0.6mm radius- CAD Drawing*
David Goodwin

**Fig 31**
*The finished ball ring shaded- CAD Drawing*
David Goodwin

**Fig 32**
*Ball Mesh Ring- CAD Drawing*
David Goodwin
Stephen Bottomley  
Sheffield Hallam University, UK

David Goodwin  
Royal College of Art, UK

**Something Old/Something New:**  
The Marriage of Digital - Craft

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**Fig 33**  
STL model, Ball Mesh Ring - 18 ct Gold - Photo Nick Jell

**Fig 34**  
Ball Mesh Ring in 18ct gold (sprues attached)- CAD Drawing David Goodwin

**Fig 35**  
Ball Mesh Ring in 18ct gold (sprues removed)- CAD Drawing David Goodwin

**Fig 36**  
Ball Rings 1999 silver and 18 karat gold, Joe Wood
Stephen Bottomley
Sheffield Hallam University, UK

David Goodwin
Royal College of Art, UK

Something Old/Something New:
The Marriage of Digital - Craft

Fig 37
*Nubring* Bracelet, Red enamel powder & resin on Z-402 digital print, 1999, Joe Wood

Fig 38
*Sphero* Bracelet, Enamel powder and resin with silver on Z-402 digital print, 1999

Fig 39
*Water Pitcher*, CAD rendered drawing, 2003, Peter Musson

Fig 40
*Water Pitcher*, Silver, 2003, Peter Musson
Something Old/Something New:
The Marriage of Digital - Craft

Fig 41
V&A Medal design - Rhino, 2002, Peter Musson

Fig 42
V&A Medal - Bronze (front face) 2002, Peter Musson

Fig 43
V&A Medal - Bronze (back face) 2002, Peter Musson
Fig 11
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