Standing Astride Two Horses
– Bi-directional Fabrication for Medallic Artists

Paul Leathers

Medallic art, a relative newcomer historically, employs traditional small-scale sculptural materials and methods while adding a conceptual narrative component. It occupies the interstitial zone between the material and the immaterial. In this presentation, I intend to examine a number of options for integrating emergent digital technologies into our practice by drawing on personal research that is both practice-based (that which leads to new artefacts) and practice-led (that which leads to new understandings of the practice).

Perhaps better known in Canada and abroad as a contemporary jeweller and sculptural metalsmith, I am a maker who sees a convergence taking place in my studio practice: one that excites me. As I wrote in a recent article, when crossing material and technical boundaries into new and uncharted territories, "I sometimes feel like a circus performer standing astride two horses."[1] Working at the nexus point between craft-based wearable and sculptural genres, the solution for me has been to try to understand the temperament of both 'horses' and find a synergistic balance between the two skill sets.

I feel fortunate to have been introduced, in the spring of 2000, to the notion of the contemporary art medal by seeing the results of the BAMS Student Medal Project which were on display in the foyer of Central Saint Martins School of Art in London, England. At the time, I was Studio Head of Jewellery & Small Object Design at the Kootenay School of Art in Nelson, British Columbia, Canada, and was excited by learning about a metalsmithing variant that I thought could provide a vocabulary of new forms for both my students and myself to explore.

As an educator, I am a firm believer in training students to work with tools which they will have access to upon graduation. I have consistently tried to apply the constraint of sourcing free, or at least inexpensive, hardware and software which students would be able to afford for use in their own studio practices. I believe in evaluating emerging technologies against established methodologies in order to seek and test for novel opportunities. Just because it's new, doesn't necessarily mean that it is better. So you can understand my somewhat skeptical response when, during an artist residency at the Australian National University's Canberra School of Art in 2001, I saw the AUD$250,000 Stratasys Fortis 400mc FDM printer which the university had just purchased for the Gold & Silversmithing Workshop.

The halfway mark in my journey towards making peace with the economics of the emergent digital technologies came with the explosion of online printing resources such as stratasysdirect.com, i.materialise.com, sculpteo.com, hitch3Dprint.com, etc. Digital files could be uploaded to equipment which would be otherwise inaccessible for the studio artist, objects fabricated, and shipped anywhere in the world. The equipment investment costs and overhead were cut out, and as-yet untried materials such as nylon and titanium could be explored.

Bernard Meyerson, IBM's Chief Innovation Officer and member of The World Economic Forum's Meta-Council on Emerging Technologies, has identified distributed manufacturing — where anyone, anywhere in the world, can access complex manufacturing equipment by uploading a digital file and having it printed and shipped locally — as a game changer. As opposed to collecting raw materials together for fabrication in centralised factories and subsequent shipment to the customer, "… The idea of distributed manufacturing" Meyerson states, "is to replace as much of the material supply chain as possible with digital information."[2] 3D Hubs is an example of an online service bureau which relies heavily on coordinating local DIY makers, who use their own 3D printers and materials, to print objects for local clients (3dhubs.com).

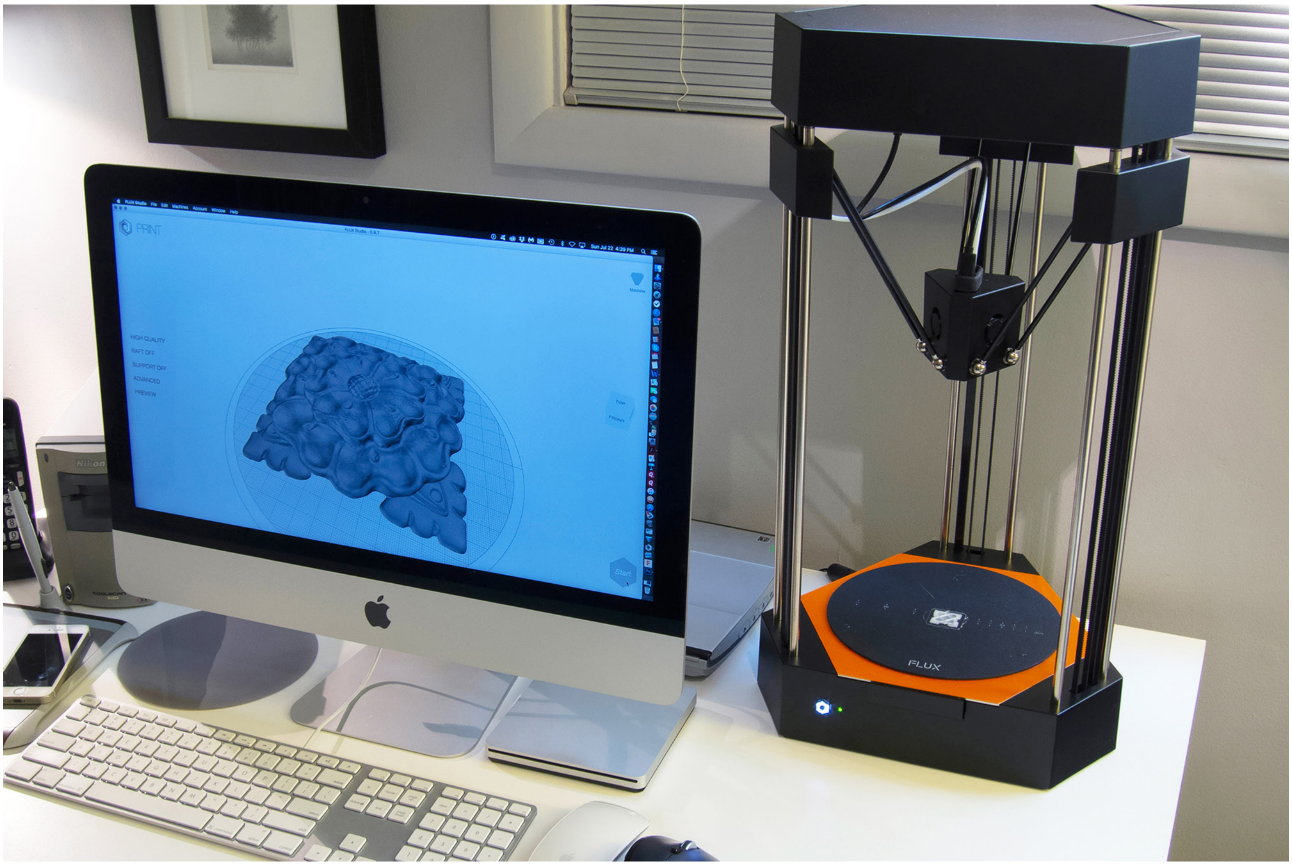

Fig 1. FLUX Delta 3D printer workstation
Photo: Paul Leathers

The tipping point came for me, however, in 2014 with the launch of the online Kickstarter campaign for the FLUX Delta 3D printer (fig. 1). With attachments for laser scanning, fused filament fabrication (FFF) printing, laser cutting, and drawing included, I was ready to take the plunge. Successful grant applications secured funding from the Alberta Foundation for the Arts and the Canada Council for the Arts to take a year's worth of time to investigate the integration of materials and processes into my studio practice. A two-month artist residency at MEDALTA in Medicine Hat, Alberta, Canada, was followed by another month-long residency, and the co-leading of a three-week master class on digital technologies for ceramic design, at The Pottery Workshop in Jingdezhen, China. While there, I observed the CNC milling of plaster slabs to create low relief drop moulds (fig. 2–4).

Having recently invested in an EORA 3D laser scanner and a KUDO3D Bean digital light process (DLP) printer, I am excited by the opportunities that all three of these cutting-edge tools provide me to explore innovative methods for integrating digital and physical design through entangled bi-directional fabrication; a process whereby existing forms are digitised, modified, and reformed through progressive iterations.[3] This allows for a conversation to be developed between the digital and more traditional making processes. Rather than being constantly immersed in the virtual world, solutions evolve from, and are input back into, a collaborative design process based on the application of both traditional and digital skills.

Gilbert Simondon, in his letter *On Techno-Aesthetics*, observes that "Art is not only the object of contemplation; for those who practice it, it's a form of action...."[4] "Aesthetics," he continues, "is not only [...]

Fig 2. CNC Milling of plaster slab for making a low relief drop mould,
Jingdezhen, China, 2017
Photo: Paul Leathers

Fig 3. CNC Milled plaster drop mould
Photo: Paul Leathers

Fig 4. Coloured porcelain form taken from the mould
Photo: Paul Leathers

the sensation of the 'consumer' of the work of art. It is also, and more originally so, the set of sensations […] of the artists themselves: it's about a certain contact with matter that is being transformed through work."[5] "One experiences something aesthetic," he concludes, "when one is doing…"[6] Doing, in new ways and with new materials, allows me to develop unexpected solutions that can be used to extend the boundaries of my art practice.

As a very general observation, medallic art would appear to be a specialist form that, unlike numismatics, derives no significant benefit from mass production and circulation. Having lived through the first Industrial Revolution — a period of deep social and technological upheaval wherein steam power was employed to facilitate mechanised production — French architect and theorist Eugène Viollet-le-Duc lamented that, "When […] mechanical methods develop, their exactitude, their even precision, their unintelligence replace little by little that fascination which belongs to everything shaped by hand."[7] "Mechanism" he continued, "has destroyed the habit of intelligent personal effort on the part of the worker, and his energies are now directed to the imitation of the cold and arid regularity of the machine."[8]

With electrified, factory-based serial production the harbinger of the second Industrial Revolution and the arrival of personal computers and the Internet the third, we are now, according to Klaus Schwab, Founder and Executive Chairman of the World Economic Forum Geneva, entering the Industrial Revolution's fourth iteration; 3D printing, and distributed manufacturing.[9] We cannot, however, afford to succumb to neo-Luddism — resisting, but eventually falling victim to technology's developments — but must rather embrace the numerous opportunities emerging from the digital realm, and then negotiate our own way with them.

Enhance your own work, rather than fall slave to the digital technologies!

As an augmentation to more traditional studio materials and methods, digital design and fabrication methods, such as computer aided design (CAD) and additive manufacturing (AM), offer a number of captivating new pathways. As opposed to the more familiar subtractive manufacturing, additive manufacturing starts with a loose material — liquid, powder, filament, etc. — and builds it into a three-dimensional form using a digital template. Unlike more typical mass-produced goods, 3D printed objects can be highly customized in order to meet the individual needs of the end user.

The I Ching, or ancient Chinese Classic of Changes, states that no good ending can be expected in the absence of the right beginning. So, in the interest of good beginnings, some observations regarding 3D printing include the following; workflow is everything. Really! NO, REALLY!! Document your steps so that you can follow them back and repeat them. There is nothing worse than arriving at a solution that you like, and then realising that you have no idea how you arrived at it. I recommend creating a library of both digital and physical 3D forms (elements) to reuse and modify. And, be prepared to deal with many hurdles.

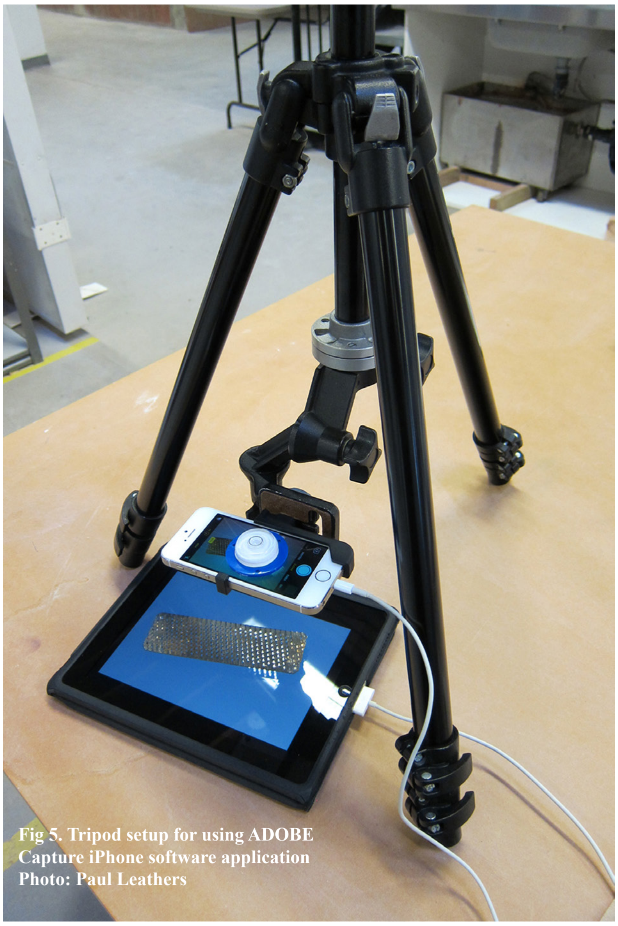

Fig 5. Tripod setup for using ADOBE Capture iPhone software application
Photo: Paul Leathers

There is often a steep learning curve for artists using engineering software as the workflow is very precise and usually not very intuitive. It begs the question; what can 3D printing deliver to the process of medallic art making that is unique? My answer is a space frame lattice, or a Chinese puzzle-like form within a form, where one can't access the inside of the completed casting.

Perhaps the most basic CAD technique that we can employ is the laying out of a reversed image or text block in ADOBE Photoshop or Illustrator in order to be able to transfer it, with a Chartpak blender pen, from a digital laser print onto a block of plaster. This technique benefits from the software application's precise character layout and kerning. One of my personal favourites, the ADOBE Capture smartphone app is useful for converting a hand-drawn image, a photo, or even a found object (fig. 5–6) to a .JPG or .SVG file so that it can be uploaded to the SELVA3D online application for extruding and converting into an .STL file. Mathematically driven possibilities for developing 3D printed forms exist through such software applications as Context Free Art, Lindenmayer, Structure Synth, Wolfram Mathematica, etc. Full-on engineering software applications are numerous and include Autodesk's user friendly, FUSION 360. If required, finished 3D models can be uploaded to a variety of online service sites for cleanup and repair (shapeways.com, makeprintable.com).

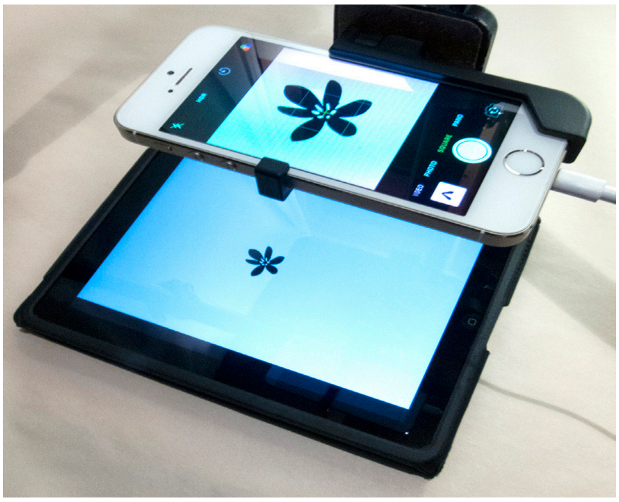

Fig 6. Detail
Photo: Paul Leathers

I find that 3D printed objects often appear unfinished; perhaps because the making process is driven by digital engineers rather than by experienced makers. A hand drawn image is both emotive and relatable, a machine made image often anonymous and sterile. Where is the presence of the hand of the maker; the expressive notation of mark making with a brush or pen? We, however, can modify the printed surfaces before committing them to the permanence of cast metal; and even afterwards, we have Dremel or Foredom Flex Shaft tools to resolve the casting's surface quality.

Current material developments of specific interest to those of us casting metal include sculptable filaments, with options such as Thibra3D's polycaprolactone *Skulpt* filament. Printed at a low extrusion temperature of 70–80˚C, this material is post-processed with traditional wax-working tools and techniques, and can be heat-worked at 70˚C to smooth out any printing lines or imperfections. Other wax-based or wax-like

Fig 7. Polymaker Polysher™
Photo: Polymaker Industrial

Fig 8. Polymaker Polycast™ models with stainless steel castings
Photo: Polymaker Industrial

low temperature filaments include MachinableWax's *Print2Cast* wax filament and *MOLDLAY* from German filament designer, Kai Parthy. These materials offer the option of printing thin-walled shells made rigid by an internal geometric structure in order to keep it from collapsing under the hydrostatic pressure of investing. Metal-filled options include Multi3D's *Electrifi* conductive filament, and The Virtual Foundry's *Filamet* that has a stainless steel 316L, copper, or bronze metallic content of over 81%. After having been 3D printed, the form can go right to the kiln for sintering into a solid metal object.

Again, Klaus Schwab observes that, "… in the future, talent, more than capital will represent the critical factor of production. […] The inexorable shift from simple digitization (the Third Industrial Revolution) to innovation based on combinations of technologies (the Fourth Industrial Revolution) is forcing companies to re-examine the way they do business."[10] While in Shanghai, China, recently, I dropped by the Polymaker Innovation Centre to meet with Luke Taylor, Polymaker Industrial's marketing manager. Originally from Leeds in England and trained as a model-maker for the film industry, Luke was generous with his time and enthusiastically offered a sizeable sample of *PolyCast*, their new SP801C polyvinyl butyral filament that has been designed specifically for investment casting. 3D Printed using regular PLA settings and with structural properties similar to ABS, the filament is compatible with Polymaker's *Polysher* (fig. 7), whereby 99% isopropyl alcohol is nebulised into a fine mist, via their Microdroplet Polishing technology, and used to chemically smooth the surface of the printed form housed within. What is most exciting about this filament is that the ash residue on burnout has been lowered to 0.003%. Luke informed me that the Chinese foundry that had cast their stainless steel test samples (fig. 8) was so impressed by the product that it is now working with a local printer farm and printing 250 kg of *PolyCast* filament per month. The disruption has begun!

Looking to the future, Bernard Meyerson reveals that, "4D printing now promises to bring in a new generation of products that can alter themselves in response to environmental changes, such as heat and humidity."[11] Who knows how the relationship between the medal and the hand will evolve over the next twenty years. Maybe one day our 4D medals will attend our approach, eagerly unfold themselves from their storage boxes, and jump directly into our outstretched hands.

Canada Council for the Arts Conseil des arts du Canada

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NOTES

1. Leathers, P.: Crossing Borders, Breaking Boundaries, *Studio Potter magazine*, Vol. 45 No. 2, 2017, pp. 41–43 (p. 43).

2. Meyerson, B.: *Emerging Tech 2015: Distributed manufacturing*, World Economic Forum (Meta-Council on Emerging Technologies) Geneva. 04 Mar. 2015, accessed from the web at https://www.weforum.org/agenda/2015/03/emerging-tech-2015-distributed-manufacturing/.

3. Weichel, C., Hardy, J., Alexander, J. and Gellersen, H.: ReForm: Integrating Physical and Digital Design Through Bidirectional Fabrication, *Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology (UIST '15)*, ACM, New York, 2015, pp. 93–102.

4. Simondon, G.: 'On Techno-Aesthetics' trans. Arne De Boever in *PARRHESIA*, Number 14, 2012, pp. 1–8 (p. 3).

5. Simondon 2012, p. 3.

6. Simondon 2012, p. 3.

7. Viollet-le-Duc, E. E.: *Dictionnaire raisonné du mobilier français de l'époque carlovingienne à la Renaissance*, tome 2, 1873-1874, p. 172.

8. Viollet-le-Duc 1873-1874, p. 172.

9. Schwab, K.: *The Fourth Industrial Revolution: what it means, how to respond*. World Economic Forum (Meta-Council on Emerging Technologies) Geneva. 14 Jan. 2016, 2018, accessed from the web at https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/.

10. Schwab 2018.

11. Meyerson, B.: *Emerging Tech 2015: Additive manufacturing*. World Economic Forum (Meta-Council on Emerging Technologies) Geneva. 04 Mar. 2015; accessed from the web at https://www.weforum.org/agenda/2015/03/emerging-tech-2015-additive-manufacturing/.