Information

This book has been produced with graphic designers as the intended audience. Those with a knowledge of the graphic design craft or printing processes will understand much of the nomenclature. I have produced a chapter and information pages for the lay person to assist in understanding the various process. The first are technology pages, these pages are placed throughout the publication and have no page numbers or descriptors and focus on technology spoken about prior. The other is Chapter 5 - The Anatomy of Banknotes. This chapter can be used as a reference throughout the publication and is complete with photographs and descriptions.
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CHAPTER 1
This research will break down the components of an ultra-secrctive industry to illustrate the importance of visual communication in an increasingly connected world...
Introduction

The purpose of this research is to explore the role of graphic design in anti-counterfeit measures, taking the modern banknote as the apotheosis of secure design. Elucidating the relationship between document security and graphic design to show why that relationship is more than portraits, national iconography and good or bad typography choices. This research will break down the components of an ultra-secretive industry to illustrate the importance of visual communication in an increasingly connected world, where cash is still king. Using publications from industry leaders, such as De La Rue (leading in security design and print for 200 years) and Innovia (creators of the popular Guardian® polymer substrate) I will demonstrate how a successful, secure document producer wins new contracts around the world by being technological innovators in tandem with graphic design craft. There is no intent, but there is a likelihood that the industry will appear monopolistic; this study lacks the quantitative comparisons necessary to affirm this as it is a small industry by design, which has a need to keep as much in-house as possible, where feasible. If the industry were to make all products, services or tender opportunities open to non industry, it would make banknote technology available to the counterfeiter. This research will answer questions within the realm of publicly accessible information. As the banknote industry is closed off, there exist methods the public are not aware of that secure third line (central bank and banknote printer authentication method) authentication as some of the cited material, accessed through interviews with industry insiders is unavailable through any other means. In February 2016, a meeting was arranged with Lachlan McDonald (an industry professional in the banknote sector) to discuss graphic designs role in both innovation, public acceptance and visual design problem solving.
Banknotes, as we know them today, are legal tender within their state of issue and are authorised by a state central bank. Modern currency is truly international, the US Dollar, The Euro, Japanese Yen, Pound Sterling and the Swiss Franc respectively are the top 5 most-traded currencies around the world (Investopedia, 2011). Some banknotes being accepted for payments in countries alongside their national notes, as in the example of Panama (Reuters Editorial, 2012) who adopted the US Dollar as a secondary banknote and planned to add the Euro to be accepted by retail and the public. For this reason and that of tourists, modern banknotes must conform to standards that make them as they may be immediately understood by the most unlearned persons (Karl Maria Michael de Leeuw, 2007).

The Introduction of banknotes to the west came from Marco Polo in mediaeval Europe, the Yuan Dynasty. He wrote “The Emperors Mint then is in the same City of Cambulac, and the way it is wrought is such that you might say he hath the secret of Alchemy in perfection, and you would be right! For he makes this money after his fashion. He makes them take of the bark of a certain tree, in fact of the mulberry tree. This they make into something resembling paper, but black.”

A later banknote issued by the Ming Dynasty around 1375 provides evidence of this almost 50 years after Marco Polo’s passing (The British Museum, 2009).
Figure 1: US One Dollar Bill - 120% magnification (Terry, 2017k)

Figure 2: Ten Euros - 240% magnification (Terry, 2017b)

Figure 2: Twenty GBP - 130% magnification (Terry, 2017u)
European Milestones

It is not until 16th July 1661 that Stockholms Banco issued the first so-called “Credityf-Zedel” (Deutsche Bundesbank, 2016), which would be the first specie note of its kind to replace commodity money with a fiat currency. Commodity money as it is referred to now is any object that people believe has value; this can include precious metals such as gold and silver or salt (from which the term salary is derived), tobacco, corn and cotton (O’Sullivan and Sheffrin, 2002). Fiat money, on the other hand, is created by securities, which are government liabilities listed on a stock exchange. There exist two types; conventional (UK debt management office, 2016) and index-linked. The Bank of Amsterdam would be the next bank to introduce a fiat currency in the 16th Century (Quinn and Roberds, 2010) and later followed by many independent banks in both France and Great Britain. It is only during the 18th Century there is “a gradual move toward fixed denomination notes” by the Bank of England (Bank of England, no date), that we get a central bank issued banknote, with which we could recognise today.

Figure 4: Credityf-Zedel paper money (Palmstruch, 1661)
Counterfeiting and punishment history

The act of coining in which a person would either attempt to mint a coin from a lesser metal or snip metal from genuine coins and re-mint a coin was an act of treason, punishable by death. Today, less gruesome sentences are handed out to counterfeiters, both in the UK and across Europe. The ECB has agreed on guidelines for all EU countries on how to deal with counterfeit Euro currency. The ECB has left sentencing guidelines to the courts of the land under €5000 (counterfeit value), with minimum sentencing guidelines for €10,000+ at six months custodial, growing in-line with the seriousness of the offence up to eight years maximum sentence (European Commission, 2013).

Figure 5: Photograph of a Bank Restriction Note. A satirical print. (Terry, 2017aj)
The Introduction of Graphic Design

The Dutch National Bank (DNB) issued the first graphically designed banknote in the 19th Century, owing to the placement and unique production of graphic elements such as typography and imagery. Early Dutch banknotes such as the Roodborstje (Robin Red Breast) provide an example of this in the form of music typefaces created by Joan Michael Fleischman, a German punchcutter. These music types were unique, so their application in letterpress printing presented itself as a security feature and could be said to have given birth to document security as we know it today.

At this time a design brief was presented to an artist in which he would work within the guidelines of a printer and generate a specific aesthetic that would be recognisable (in size, colour and security feature) as specifically DNB specie (Bolten, 2000). From this point on, the need for technical and creative skills as a collaboration proved to work well in combating counterfeiting.

Figure 6: Etching of Johann Michael Fleischmann (Preuss Type, 2016)
Figure 7: Roodborstje banknote, dated 1 Nov 1814 and written by 8 different hands. (De Heij and Van Gelder, no date)
FACT: #1

A banknote series can take anything from 3 months to 6 years to develop. There are so many elements to consider and if a central bank is making a big change, like changing substrate or denomination value, this development can take a very long time to consult, develop and design.
FACT: #2

When a counterfeiter produces banknotes, not only are they committing fraud, but they are also breaking copyright laws in many countries with regards to artists images, but that of the company designing or central bank issuing.
Aesthetic attractiveness, although a subjective quality, can be achieved with thorough research into the historical and cultural identity of the country.
The Euro Example

In 2002, 12 EU member states gave up their national currencies and adopted the Euro. The Euro would be the first transnational currency to be introduced and the last major currency to be created to date. What is different about the Euro that no other currency can boast is that it was intended to be a transnational currency from the start and its pictorial references to the ages of European style that would reflect a collective cultural heritage (European Monetary Institute, 1996).

The original design brief states “The Challenge of banknote design lies in the clever combination of security features and artistic interpretation. When Creating new European banknotes, the same considerations apply as when planning, developing and producing national banknotes. Banknotes should be: easy to recognise; secure against counterfeiting; aesthetically attractive. The fulfilment of all these requirements influences and restricts the creative freedom of a banknote designer” (European Central Bank, 1997).

Aesthetic attractiveness, although a subjective quality, can be achieved with thorough research into the historical and cultural identity of the country. In an excerpt (ANNEX Part 1) of the Design Brief for The Design of a Series of Euro Banknotes, The European Monetary Institute (EMI) state that in developing a concept note the designer must show certain features. Each banknote will show features – which could be portraits – representing a certain period in time (“age”) and an architectural feature (“style”) from the same period, thus depicting the ages and styles of Europe...
The windows and gateways on the obverse side symbolise the **European spirit** of openness and co-operation.

The winning designer was smart in his interpretation of the term “portrait” and also in his problem solving when reproducing a certain architectural style that looks like bridges you will find all over Europe, but not looking like any specific bridge. In doing this, he managed to represent the continents cultural heritage and its future aspirations of building metaphorical bridges.

*Participants are free to choose other examples or features to be represented, provided the following requirements are met: it is imperative that the designs ensure a proper balance between men and women and that political bias is avoided.*

The restrictions here produce a barrier straight away by asking for a proper balance between men and women, while simultaneously introducing an odd number (7) of banknotes. The designer avoided two other pitfalls in his interpretation of portrait; one was those mentioned above, the other is in trying not to make a portrait look like any one particular nationality, which invariably have multiple ethnicities over the “ages”. The windows and gateways on the obverse side symbolise the European spirit of openness and co-operation. The designer developed this further metaphor as a way to bypass a bias and solve the portrait issue.

The winning designs for the Euro banknotes, submitted by Robert Kalina, an Austrian national with previous experience at Oesterreichische Nationalbank in Vienna. The jury deciding the winner included international names in design such as
Wim Crouwel (the Netherlands), Nicholas Butler (the UK) and Gérard Caron (France) amongst another 11 well-known names from throughout Europe (European Central Bank, 1997).

Many news articles exist that show the Euro counterfeit during its introduction. Starting in 2003 (BBC, 2003, a, b, c, d) with low skill examples and within a few short years technical skill and large scale organised crime linked to the Italian Mafia Napoli Group taking hold in cities where the problem has no easy fix (Mucci, 2014).

The year 2000, a full year into large scale production of the Euro, regional printing started to see teething problems related to the uniformity of the process across 15 printers. Despite careful preparations, printers were receiving supplies from nine paper mills, using inks, security threads, holograms, and other materials ordered from two dozen different suppliers. All of the printing works participating in the production of euro banknotes were committed to success, bidding for orders created a mood of rivalry in which rumours about competitors gained greater credence. It was not, therefore, surprising that a problem with the appearance of a euro note leaked to the press. On July 11 the German daily Frankfurter Allgemeine Zeitung headlined on its front page that there were problems in the production of 100 euro banknotes in Germany (Bender, 2006).

One significant uniformity problem occurred when Giesecke & Devrient, the German printer confirmed that there was an issue with the 100 euro, in that a security feature that prevented photocopying, developed in the 1990’s jointly by central banks, had not been printed the same as that produced by other printing works. By the time information about the problem leaked to the press, G&D had already come up with an innovative way of correcting it, an additional printing stage. The human error had created the problem, but a working solution was developed. By the end of August, the ECB and Deutsche Bundesbank were both able to announce that the difference in appearance had been eliminated and would not disrupt the schedule for banknote production. (Heinonen and Suomen Pankki, 2015).
Banknotes

(top left) Figure 9: Romanesque gateway depicting the spirit of openness in Europe.

(top right) Figure 10: Example of raised print from the intaglio printing process in relation to flat relief printing from offset process.

(bottom right) Figure 11: Example of colour shifting ink from the screen printing process.

(Terry, 2017d, b)
(top left) Figure 12: Reverse of Ten Euro with half of serial number and screen trap visuals.

(top right) Figure 13: Reverse of Ten Euro showing full serial number EURion digital watermark.

(bottom left) Figure 10: Example of UV ink in-register with relief printing on reverse Ten Euro.

(Terry, 2017c, at)
FACT: #2

Polymer banknotes came into use in 1988 when the Reserve Bank of Australia adopted the substrate for the $10 dollar. There had been earlier attempts in the US but the technology was hampered by production issues related to ink not sticking to the surface and rubbing off.
Intaglio Printing
The intaglio printing process is the opposite of relief printing, where ink is pushed into the engraving and wiped from the surface of the engraving plate, when a substrate is applied with pressure, the result is 3D ink on the surface. As shown in the diagram above.

Top Image: Diagram illustrating the Intaglio process in cut away. (TERRY, 2017am)
Left Image: Example of intaglio (raised) next to relief background. (TERRY, 2017d)
...permanently stop producing the so-called "Bin Laden banknote"...
Banknotes in General

According to De La Rue (DLR), the future of banknote printing is secure through an average global growth of between 2.5-4.8% in Europe and South America respectively. The average growth rate for the rest of the world sits approximately at 3.1%. In contrast to this prediction, sale volumes in the banknote industry can be attributed to central bank inflation across the world and other economic and counter-criminal decisions by states around the world. The Royal Bank of India (RBI) released a statement in 2016 when they scrapped 500 and 1,000 Rupee banknotes overnight to scupper tax evaders. This act will have an impact on the number of banknotes produced in lower denominations and may also be a ploy by RBI to get the public depositing rather than mattress banking. India has a population of 1.25 billion people who use cash for almost every purchase. The central bank and government believe that higher denomination banknotes are used as a store of wealth and to evade tax. According to the report, holders of these notes will be allowed to exchange money at their bank between 10th November and 30th December 2016 (BBC, 2016). In a similar news article earlier in the year, the ECB have planned to remove the 500 Euro note as they believe organised crime mostly uses it to fund terrorism. The infamous €500 note, long associated with money laundering and tax evasion, is to be phased out by the European Central Bank. The ECB decided to permanently stop producing the so-called “Bin Laden banknote” at a meeting in Frankfurt. It had acquired its distinctive nickname in Spain partly because criminals and terrorists favour it for cash smuggling, and partly on the basis everyone knows what it looks like, but few people have ever seen it (Samuels, 2016).

What this signifies is that larger denomination notes are disappearing in favour of smaller, which in Indias case might push people to use another digital method of payment. For the Euro criminals, this could do the same.
With regards to the future of cash in general, the Bank of Canada, the Bank of England and other central banks have been researching the digital cash phenomena in the form of crypto-currency. Popularised by Bit-Coin, crypto-currency is an attractive alternative to central bank money. Both the payee and acceptor both agree to use Bit-Coin, agree a price for the goods and the value exchanged across an encrypted network known as the blockchain. It is entirely anonymous, and so media reports tend to focus on its use across the Dark Web for illegal items. Crypto-currencies continue to lead the way in innovative digital currencies, enough for the Bank of Canada to run a competition for digital banknotes (coined e-money) of a kind. This is distinct from digital payments like Apple Pay, Android Wallet and other such systems, as these payments link to debit card payments and contactless payment methods. Digital cash would be sanctioned and tied to money creation by a central bank, issued in the same way as a banknote with a serial number, except it would likely be a cryptographic digital signature. Digital cash will function anonymously like cash does today. Some of the problems associated with popular uptake of this technology would be in convincing the general public that digital money was the same as paper money, but has more functionality and would be more accessible for impaired users. This presents a problem for law enforcement in a similar way to India’s current high-denomination Rupee issue; it would be hard to police how much money is stored in a digital wallet. An e-money device would not naturally have a limit in the same way a home or a safe deposit box would by capacity constraints. There are simple measures law enforcement could put in place; technological concepts based on third line counterfeit detection, thresholds or limits, and legal requirements on the manufacturer to ensure there are security mechanisms to safeguard against criminality and for authorised access to data held on any e-money device. For the graphic designer, this also creates both a problem and an opportunity. If the future of paper money was that digital money would replace it, the graphic designer could lose a job prospect or they could benefit from the fact that public scepticism calls this new currency into question. This creates an opportunity for graphic designers and product designers to work together and bring that confidence back.
The enemy of my enemy is my friend

As the ancient proverb suggests, two parties of conflicting interest can or should work together against a common enemy. Banknote producers around the world cooperate to guard the secrets of their industry, but work independently to outdo one another in every aspect of the design, production and security of banknotes; any technical or logistical lead can increase sales by giving them first mover advantage, also known as technological leadership.

As a network, the banknote industry is very close. Expertise such as design and technical skill are drawn from the security printing industry. Machinery, design and computer-to-intaglio software is bought from companies who only sell within the industry. SICPA, a Swiss company, provides almost all inks to the industry; optically variable ink (OVIs), machine readable inks such as ultra-violet (UV) and Infra-red (IR), and regular visible inks for background and intaglio. Supplies such as the substrate, 3D and optical security devices (OSDs) such as foils, kinegrams and DOVIDs are from trusted partners and sub-divisions.

Banknote producers do not take away security features, but rather develop and adapt existing features to improve public confidence. Every aspect of banknote production from the substrate to ink technology is an evolution intended to solidify confidence in both the currency in an economic sense and the authenticity of the banknote.

Setting up a printing plant is done using industry insiders and a tight tendering process; this is due to the specific needs of the industry and the unique process on which banknotes are printed.

Once a plant is up and running, the technical skill required to manage, operate and supply and secure it is a mammoth task. De La Rue (DLR), a 200-year-old document security company, is the world leader in banknote design and production. In 2010 DLR lost 25% of its value as the
result of a paper supply issue with RBI, India’s central bank. The reasons behind the supply problem have never officially been released, but are suspected to be linked to paper quality or meeting demand.

Looking at the logistics and security surrounding the billions of banknotes that are sent around the world to central banks, media reports regarding loss-in-transit are rare. There are cases of large amounts of cash in transit not reaching their destination, but on the whole, thefts do not happen frequently. Potential thieves know that serial numbers on stolen banknotes will be reported and will eventually get them caught, a big enough theft and the central banks will choose to change the design. As was the case when a hologram original deemed lost in flight in 1998. While materials were being transferred from one production plant to another, a hologram original designed for banknotes disappeared on a flight from Paris to Munich. If the first version had fallen into the hands of a thief, there would have been a significant risk of counterfeiting. The counterfeit can analyse and have copies of the hologram before the new banknote is released, allowing them first-to-market opportunities. The new hologram had to be different from the earlier one, to eliminate the security risk. In fact, the need to produce another hologram proved to have a silver lining because the experts had not been entirely satisfied with the origination of the first but had approved it for scheduling reasons. Now that it had to be renewed, there was a good justification for moving the deadline and the new result was far more satisfactory (Heinonen and Suomen Pankki, 2015).
The **Kinegram** is a DOVID

**Left:** Figure 13. Showing three stages of a Diffractive Optical Variable Image Device as found on the 2016 Bank of England £5. **Below:** Figure 14. Showing the DOVID in a fourth stage and in wider context to the banknote. (Terry, 2017ae, ac, ad, ab)
Banknotes in General

Figure 15: This Deutsche Bundesbank image shows Infrared Ink, which shows up under exposure from infrared light rays and displays what cash machines and other bank authentication devices register. You can make out some of the features of this One Hundred Euro banknote as the Infrared ink is completed in register with other inks. (Deutsche Bundesbank, No Date)
Half of the **90 billion notes** are made by the four banknote great powers

For the estimated 90 Billion banknotes that are printed in the world each year, at least 90,000 metric tonnes of secure ink are required for intaglio, background, and number printing if only single-sided engraved printing is done. Half of the 90 billion notes are made by the four banknote great powers, the US, China, India, and Russia. The portion of the requirement can be disregarded because the government printing plants make their inks themselves. The available market for secure inks therefor requires 4,500 metric tonnes a year. It is supposed to be open to bidders. Of this available market, the Swiss company claims a modest 85%. However, even this figure is misleading. Of the four giants of banknote printing, only the Russian Gosnaxk is regarded as comparatively independent in its ink manufacturing.

It imports only binding agents - not from SICPA but from Gleitsmann Security Inks GmbH of Berlin. The Americans, Chinese, and Indians operate joint ventures with the Swiss company. Local laws often forbid importation of special inks for note printing. There are, therefore, still a few countries, including Australia, Britain, Japan, and South Korea, that make ink themselves. However, comparatively small volumes are required by these countries, and they often depend upon SICPA for technology. Only Japan goes it alone. Sicpa largely controls the world market for secure inks, regardless of how protected or available it officially may be. (Bender, 2006).
FIGURE 16: SICPA global market share in security inks (TERRY, 2017 as)
Latent Image Technology
The latent image combines a foreground and background pattern of horizontal and vertical fine lines, which when observed at normal and oblique angles will show and hide an image or text. This technology works by making use of how the eye perceives at an angle.

Top Image: Diagram showing observation at normal and oblique angles (TERRY, 2017aq)
Left Image: Example of latent image at normal observation on a Bank of Jamaica $100. (TERRY, 2017g)
Getting the process right

One major security feature of banknotes is Intaglio. This process gives notes a recognisable feel of authenticity. As with all good banknote security features getting intaglio right is critical to the success of a note, but that is not to say intaglio does all of the work, every banknote relies heavily on other features for its universal authentication.

In 2015 the Bank of Canada (BoC) released a new series of polymer banknotes in response to counterfeiting of their previous notes, a significant counterfeit case by a native would have had an impact on their rationale, although the BoC had many preceding reasons to do so. The BoC new series is not only an improvement but a total overhaul as they have incorporated foils and lens features unique to the substrate, then applied almost every other standard print feature on top. This along with the feel of intaglio, look of the print and scratches (when worn) is all trigger features for a genuine banknote.

Although the new notes have reduced the amounts of counterfeits in circulation, there's still a problem for people and business accepting the higher denomination $100 bills. This, however, is a problem that should play out as a result of those as mentioned above. Getting the process right for the BoC will yield much better results. In producing their new polymer banknotes, they have sought expertise from the substrate provider and academics around the world to solve certain design to print issues.

Improving BoC notes is a constant evolution as it is for the Euro. Banks use an indicator and benchmark measurement from the chemistry industry. Parts Per Million (PPM), which looks at how many counterfeits exist in circulation. In 1990 there were 4PPM, ranking its currency as among the most secure globally. By 1997, the rise of powerful and affordable PC's and software made exceptional counterfeiting achievable at home, and the number of fake Canadian bills rose...
to 117PPM, the benchmark for G20 nations is 50PPM. The growing concern at the BoC regarding the increasing number of counterfeits related to sceptics from other central banks about their currency; regardless of the fact that counterfeits in existence were nothing when considering the 1.5 billion genuine notes in circulation. By 2002, a BoC survey found that 129PPM had an impact on retailers who were no longer willing to accept $100 bills. Despite the BoC’s efforts in creating newer, more secure banknotes, in 2004 the counterfeiting rate ballooned to 470PPM, which is 100 times more than some G20 countries. The US at this time had 6.5PPM rate and Mexico 83PPM. It was at this point the BoC realised it had a serious problem and began looking to countries with much lower rates; Australia and polymer became the place to go (ROBERTSON, 2016).

There’s no doubt in 2015 that Canada had a much-improved PPM rate, almost 75% decrease in counterfeits handed into retailers. Many of the fakes are recognised.

Industry expert Lachlan McDonald (Head of PolyTeQ) answered some questions relating to how the industry can create banknotes that the public can trust.

PolyTeQ, a subdivision of Innovia Security (Previously Securency International) and the sole supplier of Guardian® polymer substrate, work with printers around the world who already use Guardian® to make the best of the technology. Whether it be improving print quality or recycling, believe there are four key criteria to a successful project.

1. **Have to reduce counterfeiting rates**

2. **Have to improve note durability and quality**

3. **Improve production efficiencies to whole cash cycle; ATMs etc...**

4. **It needs to be accepted by the public**
1. Have to reduce counterfeiting rates
2. Have to improve note durability and quality
3. Improve production efficiencies to whole cash cycle; ATMs, distribution systems in any market.
4. It needs to be accepted by the public.

One of the ways a banknote designer can reduce counterfeits is by making the visual elements memorable enough that an acceptor will get a feeling that something is not right with a counterfeit as soon as they look at one.

It used to be believed that a portrait would provide the necessary memorable element, but studies conducted by DNB before Robert Deodaat Emile “Ootje” Oxenaar’s 2nd series of banknotes suggested that portraits aren’t as reliable as the industry once thought. This discovery prompted Ootje to create what at the time were the worlds most beautiful banknotes featuring wildlife of the Netherlands; including the famous Snipe 100 Dutch Guilder (NLG) and Sunflower 50NLG banknotes.

Another way to reduce counterfeits is to educate the public about security features through the media, but this should only be a prompting exercise; a banknote should be able to self-verify through its features, quality of design and manufacture.

Note durability is just as much the designers’ responsibility as it is the manufacturers. The designer should be aware of substrate weak points and compose the banknote in such a way that the manufacturing process will strengthen those points. As an example, Intaglio is known to weaken areas in which it is placed. The euro features tactile lines at the edge of their banknotes, and these provide two functions. The first is to make the visually impaired aware of the value of the note they are holding and strengthen the edge of the banknote. There is a myriad of ways in which the designer can improve production efficiencies. These relate to the amount of Intaglio used front and back, negotiating smaller note size with central banks and in the choices of visual elements beyond the substrate.

Suggesting the available technology to the central bank that they can utilise in the substrate negates the need for additional security such as foils and expensive OVI’s like colour shifting ink. Maintaining confidence. People have to believe that a £5 note is worth £5.

There’s no sovereign, gold or silver standard. So there has to be a belief in that piece of paper or polymer.
The **Key** is to make a counterfeit look like one

**Left Top:** Figure 14. Obverse side of a twenty pound note showing high quality rainbow effect on hologram and half of the see-through register.

**Left Middle:** Figure 15. Reverse side showing other half of see-through register.

**Left Bottom:** Figure 16. Reverse side showing security thread. Also visible are guilloche patterns.

**Bottom Right:** Figure 17. Example of a real and a fake banknote next to each other.

(Terry, 2017u, v, t)
“In all four of those areas, design plays a major role.”

With this knowledge the banknote designer will create a piece of work that to the public will not see anywhere else. It is neither contemporary in the art world or old fashioned regarding layout or colour (the US dollar bucked this trend until they were forced to add colour in 2004). “In all 4 of those areas, design plays a major role.” PolyTeQ has a team of designers that Lachlan McDonald works in close collaboration with. They say; you have to be a project manager, a psychologist to understand how people use it [cash], a technical expert on how counterfeiters might attack the technology and understand how the production process works. Designing a series of banknotes can take between 3-6 years, this level of graphic design process requires dedication. Aesthetics are just one facet to consider when designing a new banknote. The challenge goes beyond initial concepts to more readily represent a process of innovation and composition for all visual elements in perfect harmony while incorporating available and complex security features. A banknote designer is capable of interpreting the culture and identity of a nation. The next step is to distill semantic concepts into specific techniques required to develop a banknote. As such the banknote designers role is different from that of a studio graphic designer for commercial work in that he is also an architect working with a team of specialists in the banknote industry. Their thoughts and reflections must focus on the visual design, substrates, security features and printing techniques. The designer also advises central banks
with regards to the architecture and manufacture of a banknotes aesthetics, colours, sizes, security features, substrates, and will gain valuable and insightful directions in return. The designer assures that the end product will go beyond the aesthetic concept as a true work of art, adapted to the complex techniques involved in its niche manufacture.

Design or concept for banknotes must be conceptualised with manufacturing in mind. The banknote designer sits between their central bank customer and the manufacturing industry. The design concepts that are created and presented to the central bank must correspond exactly to each step of the manufacturing process. For this reason, there must be communication between all key groups responsible for security features (Innovia Security, 2014).

Intaglio printing has a major role to play in securing banknotes. Different banks have different philosophies about the strengths and weaknesses behind it. The department at PolyTeQ firmly believes in intaglio. In a heavily counterfeited region, PolyTeQ will be handed a bundle of notes and told: "tell me the difference between [the] genuine and counterfeit ones, separate them out." There are certain triggers, certain public security features. PolyTeQ looks at trigger features and authentication features. Intaglio is often an excellent trigger feature. There are other factors there too. Everyone in Australia has a good sense of what a genuine polymer note feels like. There's a "bunch" of sensory things there, and intaglio plays a role in that.

With the new BoC notes, although many in the industry felt a sense of disappointment in the intaglio on the series, other technologies that were incorporated and the success of the project are enough to persuade critics. The impact that this will have on the public's ability to identify a counterfeit. You can get good intaglio, as with the Australian series and there’s many good examples, such as the Romanian series, which has excellent intaglio. Getting the intaglio right tends to be printer related, some are good at printing intaglio with tactility on polymer and other printers, not so. PolyTeQ and the International Banknote Designers Association (IBDA) are running projects to improve the intaglio on all polymer banknotes. They want to see the benchmark raised so that there's not a disparity between good and bad intaglio tactility. (MCDONALD, 2015)
**Left Top:** Figure 18. Obverse side of a five dollar bill from between 1999-2006. No colour present.  
**Right Top:** Figure 19. Obverse side of a one dollar bill from between 1963 - current. No colour.  
**Bottom:** Figure 20. Obverse side of a current twenty dollar bill from 2004. Colour present.  
(Terry, 2017ai, k, x)
At present there only ten intaglio masters in the world. One project IBDA is offering its members is the Intaglio Training Programme. During the printing of a Canadian banknote series, printers ran into a printing defect problem between the offset (background) printing and its registration with intaglio features. They sought the expertise of N.R. Jayaraman, a retired Govt. of India employee, who proposed many reasons for an apparent false-register; which includes moiré effect created by the four colour halftone process in commercial printing, where halftone dots are placed over each other at incorrect angles and causes a blur. Another possible addition to the problem is that one of the rollers might have had heavier ink, the roller could also be toward the end of its life, printing lighter with one colour and heavier on the other. The Bank of England 20 (series F), 50 (F) and new polymer 5 (series G) have found a way around this and added a layer of tactility and aesthetics in the process. While the Bank of Canada developed an exciting banknote series, one that is more than just intaglio, tactility must feature in a note, especially one with a recent history of high PPM counterfeit rates.

Figure 21. Polish Fifty Zloty showing intricate intaglio work with a pleasing colour tone on paper substrate. (Terry, 2017aa)
...achieving something possible has never been so elementary.
For as long as there have been fungible trading objects, counterfeiters have been creating replica items and attempting to pass them off as the real thing. Fourées/Farci (the French word meaning “stuffed”); coins with lesser metals at the core, coated with a thin layer of precious metal and cast in-between engraved dies, if done right were passible. Farci predates even coinage itself, metal ingots that imitate those of precious metals, used before coin currency have been found, which provides backing to this assertion (Markowitz, 2016).

Whether it is Lydian coins in the 8th Century BC or The Chinese Ming dynasty banknote that included the message “counterfeiting is punishable by death”, counterfeiters have been profiting from imitation since, with little care for the repercussions, and with the advancement of digital technology, achieving something passible has never been so elementary. The war between the makers and the counterfeit is a constant arms race that brings designers and scientists together on one side and their criminal counterparts, which include ingenious crystal meth addicts, wayward print experts, mafia and opportunists. Not only do central banks have to worry about criminals, states wanting to destabilise the economy of their enemies have taken up the challenge of reproducing cash as part of their covert warfare arsenal.

Technological innovations and their exclusivity help to secure, but other technologies can render the exclusivity useless when they are introduced to outside of the security printing industry.

The Counterfeits
When the general public gains access, the industry must move forward. This is evident most with the introduction of photography in 1839, resulting in colour being introduced into the security printing process. Advances in the printing industry (early 20th century) put colour printing into the hands of the counterfeiter, and the introduction of colour copiers in the 1970's would form the start of laymen counterfeiting. Response to this by the security printing industry then prompted a combinative feature approach. This is demonstrated in the examples of banknotes from this point to present day design briefs (see The Euro Example). From this stage it is known that graphic designers will be told what combinative features they will need to incorporate into their concept design submission, it specifically indicates that designers must show where these elements are placed within the design.

A modern banknote contains overt and covert counterfeit deterrents and detecting technologies, some of which date to 18th Century Western Europe, whether French, German, English or Dutch, everything from the physical security, substrate and printing process has gone through evolutions year on year in an attempt to keep counterfeits at a minimum. The industry knows it is not far ahead of counterfeiter, but the lead generates significant revenue for the companies who take technological leaps that allow public verification and therefore trust in the currency.

Early Dutch banknotes borrowed from French, Austrian and English technology and added graphic design as a tool to combat the wily counterfeits that were duplicating their currency; utilising custom cast typography, white paper (this was much harder to achieve in the 18th century), 2-sided deckle edge, guilloché patterns and Vurtheims coating to resist everything from freehand to photographic attempts at imitations. Over the years many graphic design printing crafts such as intaglio, relief printing, typographic setting, and added to over time with design concepts such as International Typographic style. Genuine producers began to engage the user through political iconography, assisting in public currency recognition and therefore awareness of security features or at the very least the feel and look of a genuine banknote.

Studies by the Dutch National Bank on the time required to identify banknotes
the public and retailers shows variations between currency. When a cash transaction between two persons is settled, one person is the payer and the other the receiver. The payer has to search in her or his wallet or pocket and recognises a banknote usually by its borders. Within this ‘flash second’ people will only verify the value of the note, its denomination. A security check is actioned if the note is not trusted. These two subjects of time spend on a banknote are discussed in two sections: Value Recognition is a flash second and security check, about 6 seconds. When tested against three banknotes, the NLG 100 Snipe 1981, Euro 50 Renaissance 2002 and US Dollar 20 Hamilton 2004, the presumed time needed for the public to recognise the value of a banknote when taken from a third party is 0.05s, 0.07s, and 0.1s respectively. This general publics recognition (or lack thereof) of security features allows counterfeits to benefit from new note introductions the world over; it has allowed North American counterfeiters to obtain substrate and even pre-watermarked paper from unwitting or unscrupulous European paper manufacturers and poor imitations acceptance in countries new to joining the Euro. An approach to understanding the different types of counterfeiters is to split them into two groups, those that have an impact on the central banks’ books and those who have little impact. High skilled and the low skilled respectively. Low skill counterfeits are easily the most ingenious or enterprising. They lack any understanding of how banknotes are produced. They see the basics; ink, paper, foil; then find ways to break them down into achievable, low budget goals. They know it is printed and made by a computer and likely don’t see the difference between that which is printed on a £100 desktop and that which is printed on a £100k Heidelberg. They understand that the general public also does not know the difference, or won’t under certain conditions EG if the transaction is on a busy night in a restaurant, the recipient is otherwise distracted. The mistake they tend to make is in using their work locally, allowing them to be traced fairly quickly. A step up from digital reproduction can be found in Lima, Peru; the number 1 producer of counterfeit US Dollars.
March 2016, Vice News released a video report, an undercover news story that highlights the quality fakes produced in the city. A similar example existed wherein crystal meth addicts operating in the United States would bleach the ink from $1 bills and reprint with the design of $20's; helping them to retain a feel, watermark and a foil strip (the two most widely known public verification methods). Rather than being an example of counterfeiting, this refers to falsification.

The other, high skilled counterfeiters range, but according to law enforcement, they all have a potential to destabilise the economies of the currency they make. More than a few stories of counterfeiters come from people who have worked in the print industry and have hit on hard times, either for their business and themselves and found that there is a community or organisation that is willing to pay for their skills, but for illegal purposes. Some counterfeiters simply discover that they are skilled and go on a printing spree, and like a locomotive without breaks, they continue picking up momentum till they have produced $250m, and the banks are accepting their fakes. Other high-end counterfeiting of banknotes is part of a wider counterfeiting and black market economy, where banknotes are no different from a pair of knock-off jeans or headphones. The printers are hired in by Mafia, and they work day and night to produce whatever currency they are asked to; in some cases, the fakes are so good, that they will print non-denominations like €300 banknotes as a joke, as is the case of the Napoli group in Italy.
**Security Thread**
The security thread found in a high number of banknotes is a main feature recognised by retail. A strip of clear plastic film which is later incorporated within the paper during the papermaking process.

**FIG. 3 is a side view in partial section of a cylinder type papermaking machine adopted for inserting the security device from a continuous strip within the paper fibers.** (Crane and Company, 1985)
Relief Printing

Used in the background printing process for banknotes, relief printing is the most common printing type in commercial printing. Ink is applied to the surface of a printing plate and is transferred to the substrate through direct contact.

**Top Image:** Diagram showing the basic relief process in cut away. (TERRY, 2017an)

**Right Image:** Example of relief (surface) background printing on 10 Euro, Europa Series. (TERRY, 2017c)
Chapter 4

Counterfeiters determined the designs we see today

There exist some cases in counterfeit history which have directly affected the technology incorporated into banknote design. Also, specific technological points in which the industry had to adapt their technique because of consumer accessible tech. In 1923 at an Interpol conference, attendees created classifications of counterfeiters; the categories of casual, political and professional. A casual counterfeiter is an individual who periodically issues a reproduced security document such as a banknote. A popular example is the holiday maker illegally solving the budget deficit of his holiday. The frequency of the issue is low, as is, relatively speaking, the financial damage. Since the amount is small, so are the chances of getting caught. However, the nuisance value is considerable (particularly since banks will not reimburse the retailer), and with the proliferation of colour copiers, computers, scanners and four colour printers, casual counterfeiting has increased over the decades of the 20th century. The early counterfeiters were acting more or less casual. The professional counterfeiter is sometimes linked to organised crime. The number of notes brought into circulation is relatively large because this professional employs a printing process. The general public will always admire the single-handed professional counterfeiter. He has an aura of heroism combined with craftsmanship and only a few numerous reports and stories about these heroic, tragic, and romantic lives are mentioned in history (Karl Maria Michael de Leeuw, 2006). The following cases underpin the arms race between the designer and the counterfeit. Appendix X shows a historical table of counterfeits and the reactions of central banks.
Arthur Alves Reis is famous as the man who convinced Waterlow & Sons (GB) to print 200,000 notes of 500 escudos for Portugal. In 1924, he convinced the banknote printer that the order was for the Bank of Portugal. He had the notes delivered to him personally and started to spend them. He was caught due to issue (serial) numbers.

Czeslaw Bojarski (Ca. 1960) counterfeited French such impeccable banknotes that Banque de France granted compensation for the exchange, but only for one occurrence. Using his basement as a production centre and working by himself for fear of being caught, upon discovery the police and experts were amazed by the quality and the display of the simple instruments that he used.

William Chaloner (Ca. 1650), a master counterfeiter. Chaloner started out as an apprentice nail maker in Birmingham, a town (at the time) famous for coining (the act of clipping or minting coins illegally). Chaloner moved to London and after being refused gainful employment took to making a name for himself manufacturing dildo sex toys. A Frank Abignail of his time, he became a quack doctor and soothsayer and later went into counterfeit coins and banknotes. In 1695, The Bank of England (BoE) released the first copperplate engraved £100 note on marbled paper. It was not until 1697 that counterfeiting banknotes became a felony. Chaloner was traced by the paper supplier and arrested. He turned ‘kings evidence’ for which he received formal thanks from the BoE, a reward of £200 and kept all of his profits from the scam. Chaloner is most famous as he was hanged at the request of Isaac Newton (the physicists) who lead the investigation and brought evidence against him to the court.

Other professional counterfeits that have started due to tragic circumstances in their lives, one such person is the Ukranian Salomon Smolianoff. Smolianoff was bankrupted in the October revolution of 1917 and turned to counterfeiting. Producing his fakes from a small print shop in Berlin. He was captured during Operation ‘Bernhard’, not to be confused with Operation ‘Bernhard’ of the Second World War, which was named after the above.

Political counterfeiting involves a deliberate attempt to deregulate and destabilise the financial structure and economy of a state and is closely linked
...the counterfeit notes were dumped in a lake...

to war and terrorism. Under government supervision, dedicated and specialised currency printing equipment reproduces the currency of the enemy country. The operation ‘Bernhard’ of the Second World War is best known and well documented. During the Nazi regime in Germany, Himmler ordered the production of perfect imitations of British banknote paper complete with watermark in a secret operation. The SS installed fully equipped printing works in the concentration camp Sachsenhausen near Berlin and prisoners collaborated with highly qualified to produce high-quality British pound notes. The name of the operation had to do with the SS officer in charge Bernard Kyüger. By the end of the war the counterfeit notes were dumped in a lake, and after their discovery, the Bank of England accelerated the implementation of the security thread. Another example is the so-called super dollar, a note so well made that experts find it hard to tell the difference, are said to be made in North Korea. This has not been verified. Regardless of origin, the supernote is the reason for the dramatic change in the look of the new 100 dollar bill. The earliest case of counterfeiting was during the Revolutionary War (1775-1783) when the British government tried to destabilise the Continental Government by counterfeiting US Currency. This counterfeiting forced people to start trading commodity currency again, the most popular being tobacco leaves. Benjamin Franklin would later play a part in printing regional currencies to re-establish the economy.
Banknotes come in all shapes, sizes and orientations. The most important production characteristics include substrate, security features, print and inks. This section breaks these down.
**Substrate:** Paper
The substrate is the flat substance that everything else is either placed onto or embedded within. Paper is the oldest form of substrate for banknotes, and the evolution of substrate is fast and constant in areas of structure such as strength and security. Paper banknotes are normally made from a blend of cotton and linen. They have a trusted and distinctive feel and have globally established embedded security features.

**Substrate:** Polymer
The next evolution of banknote substrate looks at the substrate as the first line of defense. Polymer offers security built directly into the multiple opacification layers making security 3D and potential. By definition it is stronger, cleaner and a successful series design make it safer than paper. Security is specific to the substrate, it’s expansive, embedded and in its infancy. Polymer is versatile and projects are bespoke.

**Substrate:** Paper/Polymer/Paper and Polymer/Paper/Polymer
Hybrid versions of polymer and paper substrates offer differing security and can also act as a transitional substrate for users resistant of direct polymer adoption. Hybrid substrates have flexibility, offering hybrid features and a good cross section of security features from both polymer and paper.
Non-Print on paper: Hologram
A complex patch made from multiple layers of polymer and metallic foils. The opacifying layers hold a series of images, refractive at angles that can appear as a single image moving or two completely different images when viewed from opposite sides. Some may even appear three dimensional. Holograms are used in most paper banknotes. Holograms form part of a banknotes security arsenal and the best examples are instant authenticators.

Non-Print on paper: Security Threads
Woven into the substrate, threads are the second most common security feature of a banknote. The evolution of security threads are leaps in innovation. Threads can be polymer with a metallic look, have type laser engraved to create a light transmittable feature or complex three dimensional motion threads.

Non-Print on paper: Foils
Usually characterised by a long strip with holographic features. Modern foils are made up of type and images with distinctive and bright rainbow colours. The security foils provide are valuable in user authentication. Made from multiple layers of polymer and metallic foils which hold images that appear to change with the motion of the substrate and the observers viewpoint.
Non-Print on paper:
Fibres
The substrate fibres can either be long or short, they can also be used as a certificate of authentication. Using a scanner, the authenticator can generate a fiber signature, this is then converted into a bit string and combined with a serial number and value can give a cryptographic hash and signed using public and private keys. This type of authentication is employed using machines at central banks.

Non-Print on paper:
UV Fibres
Embeded into the substrate, UV Fibres are present on a high number of banknotes. They are lit by using a UV light and can be seen as small single threads across the entire sheet in multiple flourescent colours. As the substrate does not flouresce, this can also be an indictaor of authenticity.

Non-Print on paper:
Watermark
One of the oldest security techniques in document security, the watermark is the most well known security feature. From a 3D mold of the image, the watermark is created by pressing the mold into the substrate whilst it is still wet, altering the density of the paper and applying an image that cannot be washed out. Modern watermarks are known to be high definition images and can comprise of more than one image and text.
Non-Print polymer: Lens Features
Polymer is leading in substrate based security and this is evidenced by the many lens features in Guardian®. A fascinating example of this is on the latest Canadian series brand name Eclipse®. When a laser light passes through the maple leaf, the value of the banknote can be seen on the surface directly behind. This works through light defraction and is one of the best examples of polymer based authentication methods for the public.

Non-Print polymer: Vignette
Polymers answer to a watermark, vignettes (normally a portrait) display a high definition image embedded directly into the substrate and are one of the many bespoke options for central banks when developing a new series. This type of image while not difficult to replicate on its own is valuable when used in tandem with other security elements.

Non-Print polymer: Silver Nano Particles
Displayed as an array of colour, silver nano-particles are embedded into the polymer substrate and is used to great effect on the Cordoba and the commemorative Polish Zlotty. This technology helps a genuine banknote stand out and has an extremely difficult production process. When observed as a single left to right motion, silver nano particles give instant authentication and are aesthetically pleasing when they form a design feature.
Non-Print polymer: Kinegram
These are added to the substrate as a strip. Kinegrams vary in width and height. They are characterised by a travelling spectrum of colours when tilted, but are usually a solid colour when viewed directly. Genuine kinegrams are good authenticators on newer banknotes, creases that happen early on in circulation halt the fluid motion of the travelling colours.

Non-Print polymer: Laser Marking
This innovation markedly expands the technical range of banknote design. The ultra-modern laser process is a versatile and can create any bespoke design at any point throughout the creation of a note. The outcome can be nanometer size holes that are machine readable, thinning of the substrate to create see-through effects, fine line work to create patterns in colour shifting effects and serial number engraving.

Printed and Printing Feature: Portraits
Portraits can take the form of anything recognisable and is usually a national figure, head of state, historical person, even cultural objects or native wildlife. They’re usually printed with intaglio to give them depth and produce good quality shading. Portraits were considered good authentication before the 1980’s because people recognise problems with faces. This has since been debunked.
Printed and Printing Feature: Serial Number
Most banknotes aren’t legal tender until they have a serial number. Characterised by a series of letters and numerals, each one is sequential, making every note an individual product. This is achieved using the letterpress process which gives versatility with regards to colouring and type height. A security feature of serial numbers is type size variability, which makes the production of counterfeits harder.

Printed and Printing Feature: Value Numerals
These numbers can be found on the front and back of a banknote; they can be large or small. In modern notes, the font size is large to accommodate people with limited eyesight and also for quick identification of value. Smaller size value numbers are usually produced as micro-text and can form lines that make a pattern in the central design.

Printed and Printing Feature: See-through Register
A partial image on opposite sides of the note, when held up to the light make a complete image. As a security feature, it must form part of a suite of features, as it is not impossible for printers to replicate with modern technology. Public awareness of this feature in the U.K. is very low.
**Printed and Printing Feature: EURion Rings**
A security feature that can be found on most modern banknotes developed specifically to make it harder to import high-resolution digital copies of notes into popular image editing software. The software recognises this feature as a constellation. Characterised by a series of rings covering sparse and complex areas of the background and sometimes included into the design as a value numeral.

**Printed and Printing Feature: Issuing Bank**
On the obverse side of a note, the bank’s name is customarily in a large font to indicate who the issuing authority is. Not normally part of the security suite, the name can be added to the intaglio plate to become part of the overall feel or aesthetic of the note.

**Printed and Printing Feature: Micro Text**
Characterised by its smallness, micro text is visible to those with good eyesight and easily viewable using an aid. Microtext is a security feature as most desktop printers lack the definition to produce the crisp lines making up the text. When microtext is used in the design as a repeating phrase or value numeral, it forms a dotted line when viewing unaided. When attempts to replicate on a desktop are made, the lines appear blurred.
**Printed and Printing Feature:** Guilloche
The technique has been used since the 1700’s. Characterised by an aesthetically pleasing line pattern in the background layers, they’re difficult to replicate and can be used by designers to hide non-public authentication such as a broken line or hidden micro text. Guilloche originally started as a way to counteract hand engraving of note features. The machine made lines were based on a mathematical model known to the designer alone.

**Printed and Printing Feature:** Signature of the authority
This can be the signature of an executive office holder within the issuing authority, without which the note is no legal tender. Signatures can be found anywhere on the banknote and do not perform any security or authentication role.

**Printed and Printing Feature:** Banknote Colouring
It is customary for notes to have an assigned a primary colour to help people identify the value at a glance. As security inks are custom made for the industry, colour combinations can go together, and you won’t find them anywhere besides banknotes. Also, certain colours are known to be tricky to replicate by standard equipment and also difficult to correctly calculate when being scanned.
**Printed and Printing Feature:** UV Ink
The technique has been used since the 1700’s. Characterised by an aesthetically pleasing line pattern in the background layers, they’re difficult to replicate and can be used by designers to hide non-public authentication such as a broken line or hidden micro text. Guilloche originally started as a way to counteract hand engraving of note features. The machine made lines were based on a mathematical model known to the designer alone.

**Printed and Printing Feature:** Background printing
Any item can form background print whether it is text or image. Many banknotes use background printing using an offset relief printing method because relief can produce photograph grade quality. Relief allows for security features such as screen trapping and guilloche. Background printing is for illustrations and complex layering of images which intaglio is not well suited.

**Printed and Printing Feature:** Colour Shiftink Effect
The butterfly has a colour shifting effect with a shimmer. As security inks are custom made for the industry, colour combinations can go together, and you won’t find them anywhere besides banknotes. Also, certain colours are known to be tricky to replicate by standard equipment and also difficult to correctly calculate when being scanned.
Tallow in the new polymer Bank of England £5 note... a data visualisation

A recent scandal hit the new £5 note shortly after the introduction in September 2016. It was discovered that trace (less than 100 parts per million (PPM)) amounts of animal fat known as tallow could be found in Guardian® Polymer substrate. A calculation of the amount in one five pound note was released by Vice (HARRIES, 2016). Here you can see a visualisation of the data (TERRY, 2017).

In the 10x10 grid on the opposite page, each block making up the grid represents 70,000 PPM.

Breaking down a single block into 10x10, tallow becomes visible at approximately 100PPM

There are no hard figures for the exact amount of tallow in 1 five pound note, so the visualisation is showing a maximum amount according to the molecular definition of the term “trace,” the likelihood is that it is far less.
Banknotes come in all shapes, sizes and orientations. The **most important production characteristics** include substrate, security features, print and inks.
Conclusion

In the vast arena of banknotes and document security in general, no one area can boast it is more important than any another, where banknotes are concerned, ‘first line’ authentication is most important as without it counterfeits would pass through the public and retail unchecked and unhindered.

All security elements form the basis of securing a banknote, but it’s graphic design and the wider area of visual communication that secures a banknote where it’s needed most; in the hands of the people who use them. Throughout the history of banknotes and document security there are key moments in time when securing valuable and transferable pieces of paper has lead the the threat and actualisation of capital punishment and harsh sentences. This is true in both ancient and modern civilisations. These punishments have had little to no effect on the threat posed by counterfeiter; whether that be a lone wolf, crime syndicate or state actor. The threat of counterfeiting is ever evolving. Similar to an arms race wherein the victor is the one who stays informed of modern advancements. Staying abreast of technological innovation, planning in advance for current technology to be compromised and working offensively to introduce newer innovations to defend a currency. The Euro stands as an exemplar in graphic design problem solving. The euro demonstrates that national icons like Queen Elizabeth II could be replaced by a window and people would still be able to recognise identify with it on a cultural level.

As an example of counterfeit protection, the 17 printers that produce the euro banknotes are best placed to problem solve quality control and create innovations from production issues. Whilst country by country payment forms are always increasing in volume and type, especially digital forms, cash remains king. Cash as an anonymous payment form will for some time reign dominant for those fearing the future, the black and grey market and as a
store of personal wealth. Not only is banknote production not slowing as a result of other forms of payment, it’s a growth industry. The growth is fuelled by political change such as inflation and hyper inflation, but also as a result of a distrust the banking institution and retail banking since the recession of recent years. Another factor is the growing removal of higher denomination banknotes in the fight against organised crime and terrorism. The secure documents industry, whilst in a constant battle to outdo one another for long-term central bank contracts is galvanised in its approach to fighting counterfeiting and falsification. This forces them to work together to form a defensive and offensive network of industrial supply and knowledge sharing. This is done through associations, memberships and talent recycling. The industry places an increased importance in skill standardisation over business rivalry, to the benefit of all. History has proven that a joint effort combining technology innovation, will drive competition and quality visual communication alongside mastery of printing craft has the best chance of defeating the counterfeiter and falsifier. This research holds importance for those wanting to enter the industry and places an understanding of the industry over a technical understanding of the necessary skills required to do so. It’s also the culmination of 18 months research into an industry which is so secretive that it’s difficult to find any single text that elucidates in respect of graphic design and the wider subject of visual communication in the banknote design sector. Future research in this subject would look at other forms of document security; identification, bonds, enterprise product authentication. Other possible sources include the end of banknotes in the future and the reasons why people counterfeit. Each area would provide a wealth of information and build on what has been developed here.
FACT: #3

Frank Bourassa, a Canadian citizen once produced $250,000,000 in counterfeit banknotes. He used $200m as a bargaining chip with the US Secret Service and the Canadian Mounted Police to only serve the 4 month prison term he had done already.
BOPP
Biaxially oriented polypropylene is the machine process for producing banknote polymer substrate and is also used in the food industry for packaging. It’s strength, clarity and ability to retain ink on the surface make it an excellent material for banknotes.

**Top Image:** A side on view of Guardian® polymer showing opacifying layers.

**Right Image:** Diagram showing the BOPP manufacture process. A four storey-high chamber.

(Innova Security, 2016)
FACT: #4

The US Dollar is made from a blend of cotton and linen, but unlike other paper Banknotes, denim is added to the pulp to strengthen and so make the dollar more durable. The Napoli Group (crime syndicate) call their counterfeit US dollars “jeans” as a code name referring to this.

(Jacobson, 2014)
**Holographic Foils**

Used as a security feature on most types of document security, holographic foils provide authentication to enterprise, education and identification. Hot stamping is the preferred industrial method of adhering the hologram to the substrate.

**Top Image:** Diagram showing the layers making up modern holographic foils. (TERRY, 2017aw)

**Right Image:** Holographic foil strip on Europa Series, 10 Euro. (TERRY, 2017a)
APPENDIX
## Historical counterfeits and the reactions of central banks

<table>
<thead>
<tr>
<th>Threat</th>
<th>Year</th>
<th>Central bank's reaction</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1282</td>
<td>Watermark (line mark)</td>
<td>Density</td>
</tr>
<tr>
<td></td>
<td>1661</td>
<td>First banknote with watermark (Stockholms banco)</td>
<td>Density</td>
</tr>
<tr>
<td></td>
<td>1694</td>
<td>Marbled Paper (GBP)</td>
<td>Material</td>
</tr>
<tr>
<td></td>
<td>1694</td>
<td>Gravure printing using copper plates, max 10,000 passes (GBP)</td>
<td>Geometry</td>
</tr>
<tr>
<td>Changing Value of real notes</td>
<td>1797</td>
<td>Anti erasure feature: an elaborate £-sign in front of the amount (GBP)</td>
<td>Geometry</td>
</tr>
<tr>
<td>Carving</td>
<td>1809</td>
<td>First forgeries. Number by letter press (GBP)</td>
<td>Geometry</td>
</tr>
<tr>
<td>Orig. Banknotes not uniform</td>
<td>1819/1836</td>
<td>Plate Transfer Method (hardened steel mother plate) invented by Jacob Perkins</td>
<td>Geometry</td>
</tr>
<tr>
<td></td>
<td>1829</td>
<td>First multi-tone watermark (Banque de France)</td>
<td>Density</td>
</tr>
<tr>
<td></td>
<td>1839</td>
<td>Electrotype invented by Boris Jakobi</td>
<td>Geometry</td>
</tr>
<tr>
<td>Photography</td>
<td>ca. 1850</td>
<td>Introduction of colour</td>
<td>Colour</td>
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