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The Manual Re-Assembly of Crosscut-Shredded Plastic Cards

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A method was previously proposed to facilitate the assembly of crosscut shredded paper documents by manual means. Reassembling shredded plastic cards, such as debit, credit, or identity cards presents different challenges than paper documents but can also be less complex in several respects than reassembling shredded paper. This paper outlines a procedure that was used to reassemble a small amount of crosscut shredded plastic cards in actual casework.

Key words: Questioned documents, shredded documents, document reconstruction, plastic cards, debit card, credit card

Introduction

This paper is a continuation of a paper (Olson, 2013), which was inspired by two cases received in 2011 and 2012. The evidence in the first consisted of a small bag of shredded documents of mixed media, and the second case included a small bag of shredded plastic cards. They were both acquired during investigations into the filing of false tax returns, done in the names of persons whose identities had been stolen.

There are several references in the literature dealing with the sorting and handling of torn documents (Osborn, 1929; Harrison, 1958/1981; Hilton, 1982; Peace, 1982; Gencavage, 1986; Morton, 1989/1990; Hammond, 1994; Ellen, 1997; Levinson, 2001, Vastrick, 2004; and Kelly, 2006). At the time of these cases, only four papers were found that dealt specifically with machine-shredded documents (Vail, 1978; Schuetzner and Commella, 1997; Herbertson, 2002; Nobles, 2008) to which a few have since been added (Moryan, 2013; Olson, 2013), as well as a consensus standard (SWGDOC, 2013). There are papers in the literature that discuss the forensic examination of credit cards (Sang, 1985 and Morris, 1996), but none have dealt specifically with the reassembly of cut or shredded plastic cards.

While working the first shredded paper case, the author developed a methodology for the manual reassembly of crosscut "shred", which involves the following basic steps:

- sorting the shred using various characteristics, such as coloring, size, shape, and presence of text or writing
- selecting a sub-group of fragments to assemble and then arranging them in an organized manner
- making associations between the fragments
- assembling associated fragments on an appropriate medium, and
- preserving and documenting the results.

The author also outlined a novel method to diagram the "shred pattern" – the overall scheme into which a document was shredded. If the shred has been organized and arranged adequately, then finding a fragment to fit a specific void in the pattern is easier than by means of trial and error.

There are many types of plastic cards with various purposes, including, but not limited to:

- Financial – e.g., credit or debit cards
- Identity/Identification (typically government-issued) - identification cards, driver's licenses, state identification cards, immigration status cards
- Membership – to a health/fitness club or social organization

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- Buyer's rewards – to record purchases made for points or credit for future purchases, and
- Gift cards - for use at a store or online website.

It is possible that any of these types of cards may be either: 1) the object of a crime, or 2) used to identify a victim or a perpetrator of a crime. Because many of the cards contain identifying information and/or incriminating evidence, they could be shredded to cover up a crime.

In mid-2012, the author received a second shredded document case, involving plastic debit cards. A common type of fraud investigated by the author's employer is the submission of false tax returns by one or more individuals. Often the names and identities of innocent persons are stolen by the perpetrators. In this particular case, the refunds from the fraudulent returns were downloaded onto reloadable debit cards and then cashed or deposited elsewhere. Some of the cards bore signatures or the embossed names of individuals who were victims of the fraud. At some point the perpetrators attempted to get rid of the evidence by shredding the cards, which, fortunately, were obtained by investigators during the execution of a search warrant. The evidence submitted consisted of a small evidence bag of shredded plastic fragments.

Many types of modern paper shredders are also equipped to shred plastic (like cards or compact discs). The reassembly of crosscut shredded plastic cards is generally not as difficult as the reassembly of paper documents for several reasons (unless the cards have been shredded by a high-security micro-cut or confetti-cut machine):

First, plastic shred is more substantial than paper shred, so the plastic fragments are both larger and easier to handle than paper.

Second, there are fewer fragments to assemble per "document". The typical card size is about 3.375 to 3.5 inches horizontally by 2.125 to 1.725 inches vertically (Sang, p124). An 8.5 by 11-inch document when shredded may produce 200 to 300 fragments, while a plastic card may produce only about 30 to 35.

Third, once the type of card and a couple of identifying features are determined, it may not be difficult to locate an exemplar to use as a guide to reassembly, either through an online search or by contacting the manufacturer or distributor.

Finally, only certain portions of a card are necessary to reassemble to provide useful information.

Although the procedures here will work with assembling any type of card, the remainder of the article will pertain only to debit cards, which were the type of cards being assembled in the author's case.

On the front (obverse) side of a typical debit card, the most critical portions to restore are:

- The name of the financial institution
- The card number, and
- The cardholder's name (if present), and

On the reverse side:

- The cardholder's name/signature;
- The Card Verification Code (a three- or four-digit number used for authentication of a card when it is not available for inspection during a transaction).

Although, historically, the above information was separated between the front and reverse sides, at least two current cards in the author's possession have all the identifying information on the same side.

The method

The following are the steps of the method (Olson, *ibid*) revised for plastic cards, which need not be performed in the order listed. They are explained in detail below:

1. Estimating the number of cards
2. Sorting the shredded fragments
3. Selecting a subgroup of shred to assemble
   a. Flattening shred
   b. Turning shred the same side up
   c. Arranging by shred direction
   d. Arranging by shred angle
   e. Arranging by shred size
4. Associating shred w/similar text or design
5. Assembling the shred
   a. Selecting a cluster of associated shreds
   b. Choosing a substrate for assembly
   c. Drawing a template
   d. Placing an exemplar underneath
   e. Beginning assembly on reference line
   f. Creating an alignment grid
   g. Drawing the shred pattern
   h. Continuing assembly until finished
6. Finishing the project
   a. Verifying assembly of the completed document
   b. Recording the final appearance of the assemblies
   c. Preserving the evidence for disposition

1. Estimating the number of cards

Estimating the number of cards present is an optional step which will give the examiner a very rough idea of the extent of the project.

1. Weighing. This could be done at any time, at the outset using the original container or later after a sub-group has been selected for assembly. Weigh the container and shred. Empty and weigh the container. Weigh a couple of cards of a similar type and calculate a mean card weight (a sample of cards in the author's possession were found to weigh between 5-6 grams). Divide the shred weight by the mean card weight to determine an estimated number of cards present (Mockrzycki, 2015-2016).
2. Counting corners or some other prominent feature. This is easier after a sub- group of similar type cards has been compiled. Find a visible feature on the card that is common to many of the shreds, e.g., a single letter in a name or logo or a particular portion of a rectangular logo or hologram. Count the number of appearances of that feature to determine a rough estimate of the number of cards.

2. Sorting shred into subgroups

It should be obvious from the outset if the shredded material contains more than one type of card, due to the bright colors of plastic and ink used in their production. In the case example highlighted in this study, shred from at least two types of cards were present: one group with a gold metallic background, and the other with a silver metallic background.

Different types of cards will have different features. For example, some have numbers and/or cardholder names that are printed on the surface, while others are embossed into the plastic.

The card shred should be sorted into subgroups, based on:

- Color(s) of the background,
- Color(s) and design of the logo and/or printing,
- Color(s) of card stock (visible from card edge – e.g., white, red, green)
- Name of the financial institution
- Type of card (e.g., American Express, MasterCard, Visa)
- Whether identifying text (numbers or names) is embossed or printed on the card surface, etc.

The following references outline sorting methods for shredded or torn paper documents (Olson, pp18-19, *ibid*; Schuetzner and Commella, *ibid*; Hammond, *ibid*; and Vail, *ibid*).

The initial sorting can be significantly time-consuming and may take several months or longer to accomplish. Because it requires little skill except for a good eye, sorting can be a communal project if help is available.

The time required is contingent upon the number of cards shredded, the size of the shred, and the amount of variation between the cards shredded.



FIGURE 1. *Gold and silver card shred being sorted by background color and other characteristics/features.*

The gross sorting can be done into various containers (e.g., boxes or trays), in an appropriate secure location into some type of covered receptacles, to prevent the shred from being disturbed.

The feasibility of developing fingerprints from reassembled shredded plastic material is not generally known at this point but is worth consideration. As a precaution, from the outset one might consider wearing latex gloves and/or using forceps for handling the shred, if there is a chance that the reassembled card may later be examined for fingerprints.

3. Selecting a subgroup of shred for assembly

The sorting process should ultimately "reduce each pile to its lowest common denominator" (Vail, *ibid* , p9). After the initial sort, a subgroup of related shred is selected for assembly. One might choose the smallest pile of shred with which to begin, or with the cards likely to be most critical to the case (of a certain card type or belonging to certain individuals).

3a. Flattening and arranging the shred

Crosscut paper shred typically have curled edges which make them difficult to handle, so they need to be flattened. By contrast, debit cards, being made of a rigid plastic, are often deformed on one lateral edge or at one end only. Sturdy forceps or needle-nose pliers are useful for straightening the curled end, so that the shred can be arranged on flat surfaces for sorting and reassembly or for scanning.

3b. Turning the shred the same side up

The shred in the selected subgroup should be laid out and further sorted. This can be done large flat surfaces, in box tops, trays, or other types of shallow or compartmented containers.

Oftentimes, plastic card shred will have printing on both sides. It was sometimes easier to reassemble the front side of a particular card, and other times the reverse. It is helpful if both sides of the shred can be made visible, so the optimal way to lay them out is by placing the shred on a sheet of low-tack clear plastic, so the examiner can turn the sheet over to see the other side. As an alternative, one or both sides of the sheet can be scanned, and images of one or both sides can be printed for reference while reassembling.

The following are additional methods that can be used for further sorting the shred.

3c. Determining and arranging by shred direction

An additional way to sort the fragments is by determining the shred direction (that is, the direction that the card went through the shredder).

Paper shredders may be equipped with cylinders with a variety of cutting surfaces, but shredders designed for shredding plastic cards/ compact discs (except those of the micro- cut variety) usually have v-shaped blades, which produce a distinctively shaped fragment with an arrowhead/caret/chevron at one end, and a notched "arrow tail" at the other.



FIGURE 2. *Shred being sorted in categories in a compartmented container*

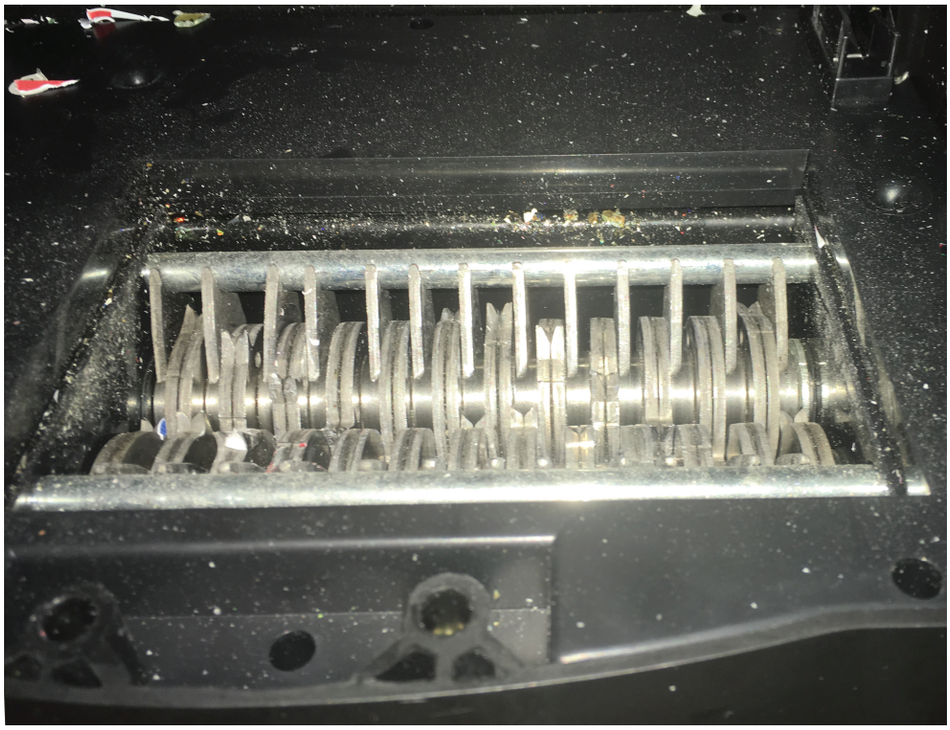


FIGURE 3. *The v-shaped blades of a table-top card shredder.*

Research by the author determined that this arrow points toward the leading edge of the item as it went into the shredder (McDonald, *ibid*, p14). The shred can be further sorted by this shred direction.

3d. Sorting by shred angle

Another useful sorting tool is separating shred based on the angle the card went through the shredder (the shred angle).

A shredder primarily designed for cards and discs typically has a long thin slot (called the throat) slightly wider than the diameter of a compact disc. It may also have a slightly larger opening in the middle about the length of a plastic card.

A card may be fed into a shredder horizontally, vertically, or at any angle in between.

No matter how a card was shredded, a pair of angles will be created at the card edge (shred angles, Olson, *ibid* , pp21-22). These angles are not necessary to measure, only to observe. The shred can be further sorted by the shred angle.



FIGURE 4. *Shred from different cards all oriented in the shred direction (downward). They were shredded in different orientations, as evidenced by the direction of the printing.*



FIGURE 5a. *A card being shredded sideways (horizontally)*



FIGURE 5b. *A card being shredded vertically*

3e. Sorting by shred size

Measuring the mean shred width and creating an alignment grid

Measure the width (narrowest dimension) of several shred and determine the mean value. This allows the creation of a grid of parallel lines for aligning the shred during assembly (in a later step). This is done most precisely before assembling the shred; however, it is also possible to create the alignment grid once the assembly has started.

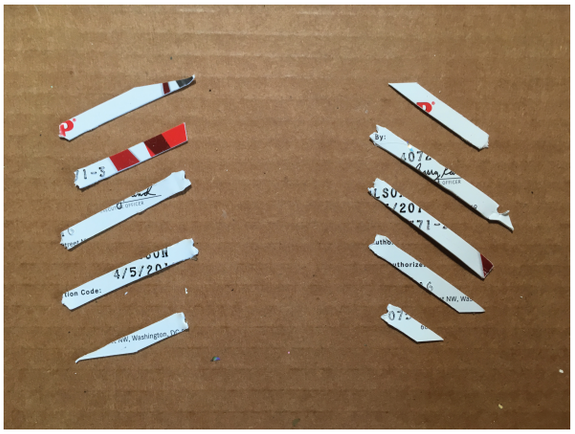


FIGURE 6. *Cards of the same design sorted by two different shred angles.*

Measuring/comparing the mean shred length(s)

Many crosscut shredders are designed to cut the shred into one uniform length (although shred on the card's borders will be of a variety of lengths).

Other shredders, due to a different arrangement of the cutting blades, cut shred into two lengths (Olson, *ibid* , p22). (This occurred both with the shred in the author's cases, and with two shredders the author had access to.) The two sizes of shred typically alternate in adjoining rows in an assembly, so sorting the shred by size can be another useful step in preparing shred for reassembly.

4. Associating shred bearing similar texts or designs

During the sorting process, potential matches are bound to be found, and these clusters should be segregated. Clusters of card shred can be associated on any flat surface (e.g., sheet of glass, cardboard, or tray), but the author found it best to place shred on a transparent low-tack laminate material, so that it does not move yet can easily be removed and placed elsewhere.

It should be remembered that the fragments of highest value for reassembly on a debit card are the following:

- Type of card (e.g., American Express, MasterCard, Visa)

- Brand name/Issuer
- Card number
- Owner's name, and
- Signature block.

5. The document assembly

5a. Selecting a cluster

It is likely several clusters of two or three fragments have already been associated. Select one to begin the assembly, preferably a cluster with shred along one of the four edges.

5b. Choose a substrate on which to assemble it

A clear plastic laminate material worked best in the author's case. It is transparent and it has an adhesive side on which to attach the shred.

There are at least two types the author used:

- Pressure-sensitive single-sided laminate sheets or rolls (like those used to laminate Electrostatic Detection Device lifts).
- Even better are plastic laminate pouches, which are two plastic sheets attached on one edge like a hinge. One sheet is thinner and has an adhesive side on the inside. The other sheet is usually thicker, without adhesive and is placed over the other to protect what is inside. These come in permanent or repositionable varieties. The author prefers the repositionable type because the adhesive is weaker, and sheets can easily be separated to place additional shred. These pouches tend to be expensive, but an 8 ½-inch by 11-inch sheet is large enough so that four cards can be assembled per sheet, and it can later be cut to separate the individual cards.

5c. Drawing a template for assembly

Using a debit card as a guide, draw an outline of the card on the uppermost (shiny) face of the laminate with a fine point permanent marker. Card shred can be assembled without this step but having a template and superimposing the shred pattern on it can help you associate shred on other parts of the card with no neighboring pieces. Alternately, a pair of parallel horizontal or vertical reference lines can be drawn using one of the dimensions of the card as a reference.

5d. Obtaining an exemplar card

It can be helpful to have a known exemplar of the type of card being assembled – the submitting investigator may be able to obtain one. The exemplar card can be placed underneath the template to assist in shred placement/alignment. Or the examiner may scan both sides of the exemplar card in a 1:1 proportion, and print them on one sheet, so that either side may be referenced.

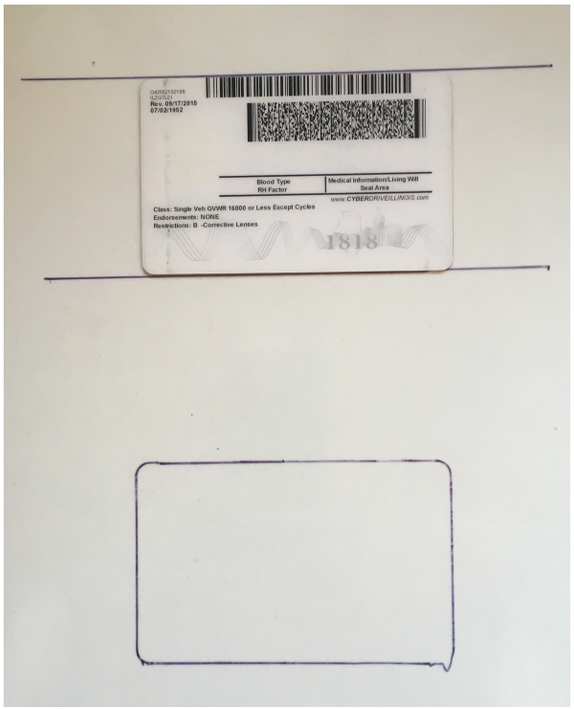


FIGURE 7. *Two types of templates drawn on a piece of laminate: a pair of horizontal reference lines with a driver's license (above), and the outline of a typical card (below).*

5e. Beginning assembly

The examiner will have to decide on which side of the card to begin assembly (which will probably be based on the number of associated fragments one has). The author found it more difficult to place the embossed printing side face down on the adhesive because there is less surface area to adhere.

Place the exemplar card (if available) underneath the template to assist in shred alignment. Place the shred over the appropriate place on the exemplar or place the assorted shred along one of the reference lines.

The assembly might proceed very well at this rate, if pieces are found in the sorted and arranged shred that fit adjacent to pieces on the assembly.

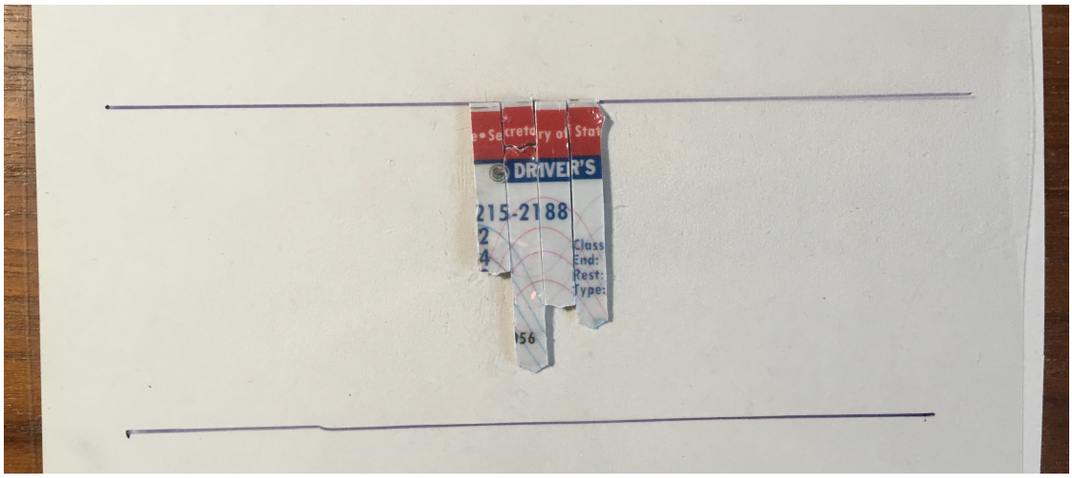


FIGURE 8. *Attaching ID card shred to the laminate using the upper reference line.*

If not, the next two steps involve creating two grids, which will define the shred pattern produced by the shredder.

5f. Creating a grid of strip cut lines (the "alignment grid")

This step involves preparing a grid of parallel lines that are spaced at the mean shred width, as though the card was being cut in a strip cut shredder. This grid does not have to be large, only slightly larger than the typical card. This is the strip cut or "alignment" grid, which can be used as a guide for assembling all cards shredded by the same machine. There are three different ways this could be prepared:

a. On a transparent substrate (document protector or piece of acetate film), draw a grid of parallel lines using a fine point marker and straightedge. Position them at the spacing of the mean shred width. Parallel rulers or a rolling ruler used in drafting work well for this task.
b. Prepare and print a table in a word processing program using the mean shred width as the line width. (See the method used to make a grid for measuring line spacing on machine-printed documents in Flynn, 2006, pp166-167.) Print the table onto paper or transparent film.
c. Make a rough grid using the document actually being assembled. Once several adjacent rows of shred have been assembled, turn the assembly over, after placing another transparent sheet or the adhesive paper backing on top. Trace over the longitudinal cut lines with a straightedge and a fine point marker, drawing over as many cut lines as are assembled. The remainder of the grid can then be extrapolated by adding additional parallel lines at the same width.

This latter method seemed to work reasonably well with shredded debit cards, although the lines are often not completely straight. In several instances, the card was found to have been twisted slightly in the horizontal plane as it was shredded.

5g. Drawing the shred pattern

When sufficient pieces are put in place, a zig zag pattern of their terminal edges is likely to appear. The document assembly should be turned over. A line can be drawn on the plastic substrate with a colored fine point marker to connect the centers of one end of the shred fragments in every other column/row. The line can be projected in both directions onto every other column/row until it reaches the boundaries of the template. A second set of parallel lines can be drawn through the other cut ends of the same fragments.

Another set of crosscuts will occur in every other adjacent column/row. Lines can be drawn in the same or a different color though the center of these cuts as before and continuing in both directions to the borders of the document template.

The resulting diagram should approximate the pattern into which the card was shredded. Any remaining shred in this group can now be

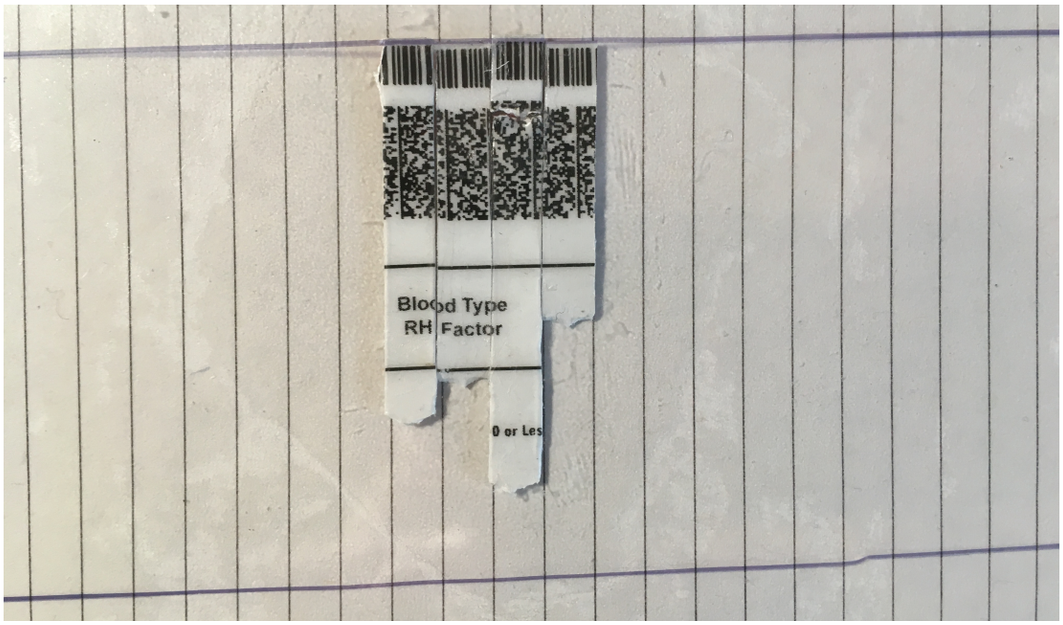


FIGURE 9. *The alignment grid (printed from a word processing program) lies underneath the ID card being assembled.*



FIGURE 10. *Lines drawn through the cut ends of the fragments in columns 1 and 3 and extrapolated in both directions.*

compared against the voids in the pattern to see where they might have originated. Based on their size and shape, they can be fitted into the place in the assembly where they appear to belong whether or not they are touching other fragments.

5h. Continuing assembly until finished

Assembly of the card can be continued from the remaining shred within that subgroup. If the shred has been sorted and arranged using the steps above, the task of finding a piece of the

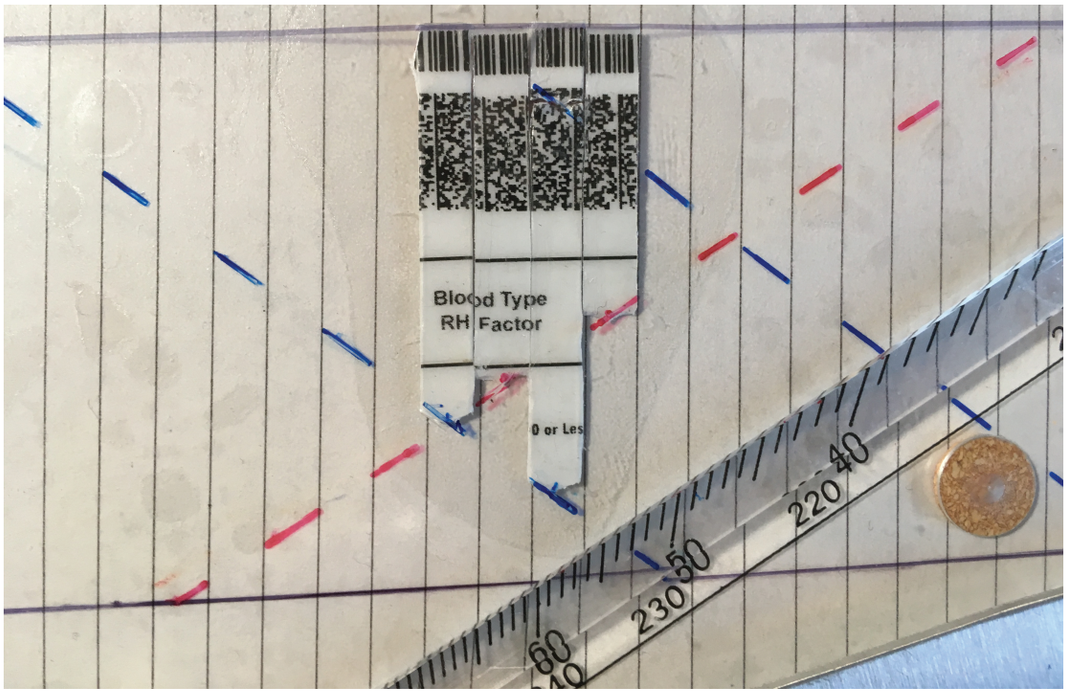


FIGURE 11. *Lines drawn through the cut ends of the fragments in columns 2 and 4, extrapolated in both directions.*

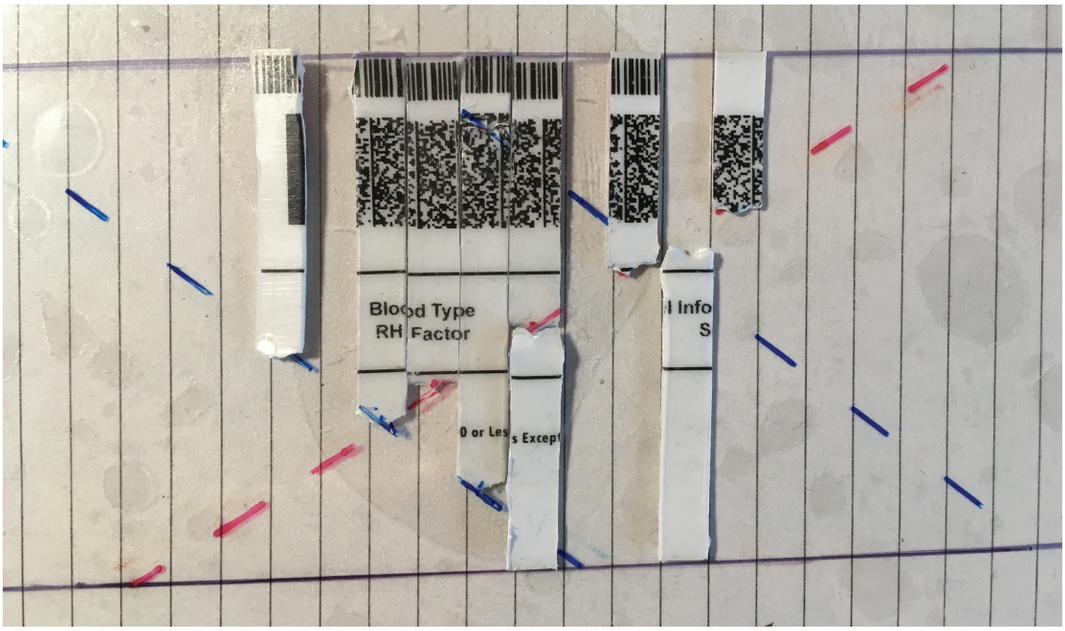


FIGURE 12. *Additional ID card fragments placed onto the pattern where they appear to belong, due to their size and the printing that is visible.*

right size, shape, and design to fit a void in the pattern should be easier. If critical pieces are still missing, one may have to go back to the unsorted shred or another similar subgroup.

Assembly need only continue until enough of the card has been assembled to reveal the identifying information of the account or account owner.

6. Number/letter restoration and decipherment

If a card has been shredded in the transverse or horizontal direction (across the widest point of



FIGURE 13. *The assembly of a debit card that has shredded sideways, so that only the upper portions of the card numerals are visible.*

the card), numbers or letters on the card may be cut through the middle and be only partially visible on an assembly. In the author's case, there was one such card in which only the top portion of the card number was present. The lower portion could not be found among the remaining sorted shred.

The missing portions may still be determined by a couple of methods.

First, cards issued by a certain bank/financial institution typically have a number starting with the same digits. The card number may be 13, 15, or 16 digits arranged in small groups depending upon the type of card and issuer (Sang, 1985, p124).

Next, if one or more exemplar cards have been found, they can provide an example of the font used for various numbers/letters. In the past, typical card fonts were OCR-A, OCR-B, and Farrington 7B for embossed characters *(ibid.)* but nowadays, many different fonts may be used for printed characters.

Finally, if no exemplar cards are available, fragments of cards among the questioned shred may provide examples of other characters. In the author's case, the missing characters were numerals. On other cards of that variety, the numerals "1," "4," and "6" were all found to have a variety of pointed tops; the "3," "5," and "7" had flat tops of various lengths with a descending stroke at different angles; and the "0," "2," "8," and "9" had rounded tops of various diameters.

Once examples of all the digits are located, they can be scanned and then the questioned and known images compared by superimposition using, for example, image enhancement software (e.g., Adobe Photoshop™) or an image enhancement instrument (e.g., Foster and Freeman Video Spectral Comparator™ or similar).

Using these methods, it may be possible to deduce the entire missing number, or at least most of it, providing a couple of options for the investigator. One must interpret carefully because portions of some numerals are indistinguishable in certain fonts.

An example of report wording follows : "The card number has been deciphered to read either: "1234 5678 9012 3427" or "1234 5678 9012 3497". A cautionary statement may also be included, such as "This interpretation is the opinion of the examiner and other interpretations may also be valid." or "This number is open to interpretation."

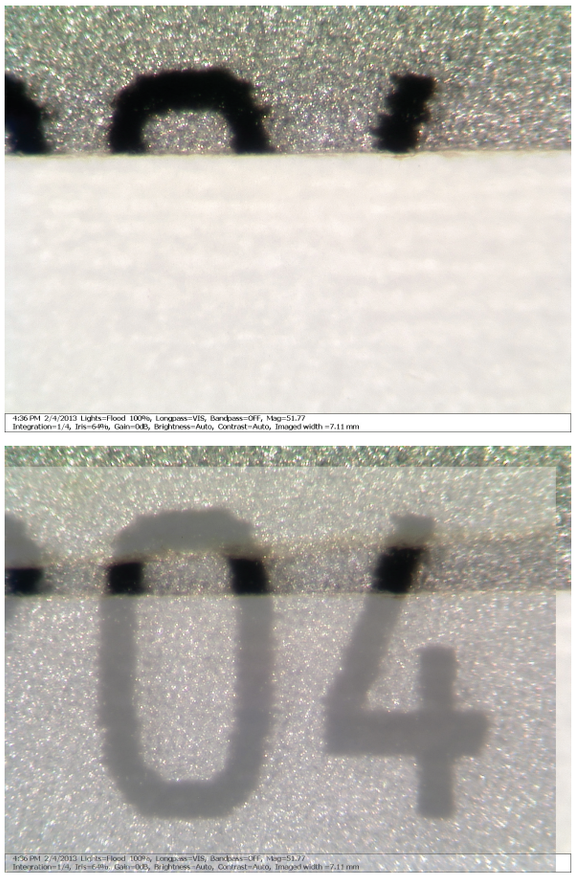


FIGURE 14a/14b. *left: the upper portion of two numerals; right: these match only the "0" and "4" when a known standard is superimposed.*

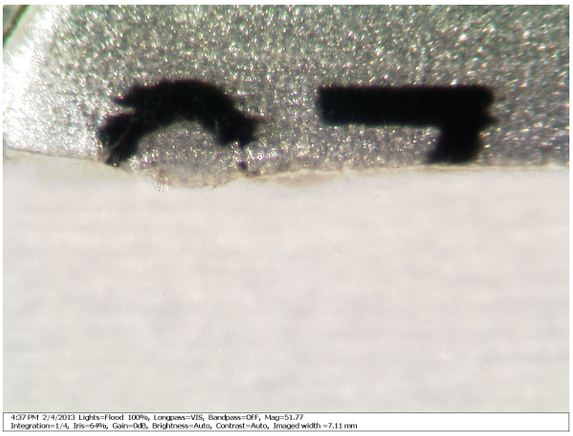


FIGURE 15a. *Another section of the card with two partial numbers.*

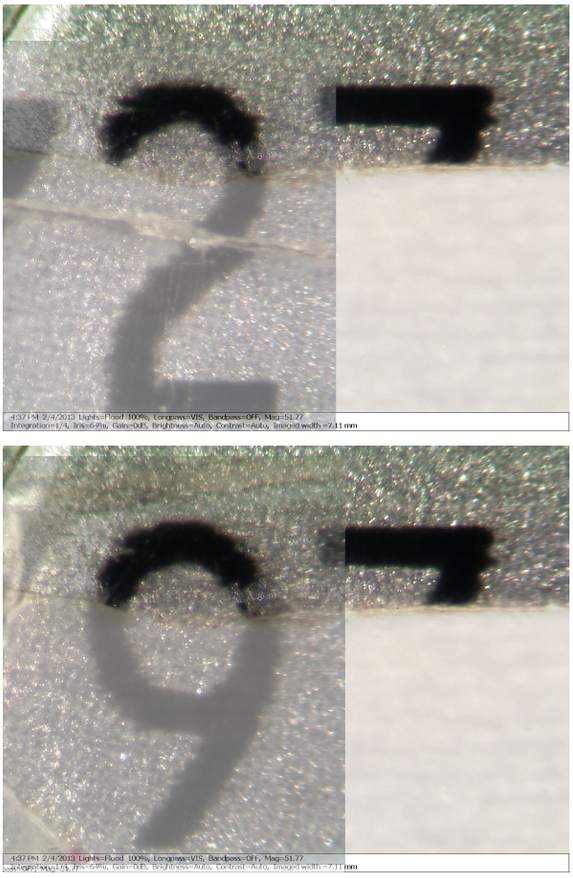


FIGURE 15b/15c. *A reason why care must be taken in interpreting the number. When superimposed, both numerals "2" and "9" fit the first digit.*

7. Finishing the assembly

7a. Preservation of the evidence

At some point, the examiner and/or the submitter will determine that enough has been accomplished. If the assembly were done on single-sided adhesive rather than a laminating pouch, a sheet of clear plastic could be placed over it to secure the results. Sheets of this type of plastic are available in booklets or rolls in art stores, or alternately, plastic document protectors could be used. Any remaining shred can be packaged (preferably in its sorted state) and returned.

7b. Verifying assembly of the completed documents

As with any type of fracture match examination, it is recommended that the completed assemblies be verified by another examiner (Hilton, *ibid*; Schuetzner and Commella, *ibid*; and Olson, *ibid*). This can be aided by magnification, as well as the use of various types of illumination (e.g., ultraviolet) and filters. The edges of plastic card shred are often stretched and distorted. This is an especially important step, because, as opposed to dealing with paper shred, there are no paper fibers that can be observed to prove a match.

7c. Recording the document's final appearance

The final appearance of the completed assembly should be recorded, which can be done by scanning images (the author made a 300dpi color bmp image of each side). Images of the fronts and the backs were sent to the investigator as they were reassembled so that the cards could attempt to be traced back to their owner or point of purchase. The finished assemblies in the author's case were provided to the submitter, along with the remaining evidence.

Outcome

In the author's 2012 case, forty-six full or partial reloadable debit cards (issued by three different financial institutions) were assembled.

Summary

A methodology developed by the author for reassembling shredded paper also works with shredded plastic cards, with some slight modifications. The reassembly of plastic card shred is, in many ways, easier than reassembling paper shred, and fewer fragments need to be reassembled to determine the owner/identification of the card or account.

References

Ellen, D. (1997). *The Scientific Examination of Documents: Methods and Techniques*, Taylor & Francis, Bristol, Pennsylvania.

Flynn, W. (2006). Typography. *Scientific Examination of Questioned Documents*, 2nd Edition. J.S. Kelly and B.S. Lindblom, editors. Boca Raton, FL: CRC Press, pp. 166- 167.

Gencavage, J. S. (1986). The Examination of Torn or Cut Paper. Presented at the American Society of Questioned Document Examiners meeting, September 21-25, 1986.

Hammond, D. (1994). Paper Reconstruction: A Methodology. Presented at the Southeastern Association of Forensic Document Examiners meeting, April 29-30, 1994.

Harrison, W.R. (1958/1981). *Suspect Documents, their scientific examination,* 1981 reprint of the 1958 ed. Chicago: Nelson-Hall, Inc, p.460.

Herbertson, G. (2002). *Document Examination on the Computer: a guide for forensic document examiners.* Berkeley, California: WideLine Publishing, pp. 147-150 (citing Gibson, R. E. (2002). Computer-Assisted Reconstruction of 'Cross-Cut' Shredded Documents. Presented at the SWAFDE Spring Meeting, San Diego, California, April 27, 2002).

Hilton, O. (1982). *Scientific Examination of Questioned Documents*. New York: Elsevier North Holland, Inc., pp. 131-132.

Kelly, J.S. (2006). Care and Handling of Documents. *Scientific Examination of Questioned Documents*, 2nd Edition. J.S. Kelly and B.S. Lindblom, editors. Boca Raton, FL: CRC Press, p. 23.

Levinson, J. (2001). *Questioned Documents: a lawyer's handbook*. London: Academic Press, pp. 132-135.

McDonald, M. and Olson, L.A. (2013). A Comparison of Class Characteristics among Several Crosscut Shredders. *Journal of the American Society of Questioned Document Examiners*, Vol. 16, No. 1, pp. 3-15.

Mockrzycki, G. (2015-2016). Federal Bureau of Investigation, personal communications.

Moryan, D. (2013). Shredded Document Reconstruction. *Journal of the American Society of Questioned Document Examiners*, Vol. 16, No. 2, pp. 25-30.

Morris, R.N. (1996). The Manufacturing of Genuine Credit Cards. *Journal of Forensic Identification*, Vol. 46, No. 3, pp. 286-293.

Nobles, K., and White, K. (2008). Shredded Paper: A Sticky Situation. Presented at the Southeastern Association of Forensic Document Examiners meeting, Atlanta, GA, April 18.

Olson, L.A. (2013). An "Ideal" Methodology for Manually Assembling Crosscut Shredded Documents. *Journal of the American Society of Questioned Document Examiners*, Vol. 16, No. 1, pp. 17-29.

Osborn, A.S. (1929). *Questioned Documents*, 2nd Ed. Chicago: Nelson-Hall, Inc., pp. 23- 24.

Peace, L.L. (1982). The Examination of Torn and Perforated Documents. *Canadian Society of Forensic Science Journal,* Vol. 15, No. 3&4.

Schuetzner, E. M. and Commella, K. (1997). The Shredded Paper Puzzle: The Reconstruction of Shredded Documents. Presented at the American Academy of Forensic Sciences meeting, February 17-22.

Sang, J.L. and H.L. (1985). Credit Cards and the Forensic Document Examiner. *Forensic Science International*, Vol. 28, pp. 121-129.

Scientific Working Group for Documents (SWGDOC). (2013). Standard for Physical Match of Paper Cuts, Tears, and Perforations in Forensic Document Examinations. Online at www.SWGDOC.com.

Vail, C.L. (1978). Reconstructing Shredded Documents. Antioch School of Law.

Vastrick, T.W. (2004). *Forensic Document Examination Techniques*, Altamonte Springs, Florida:IIA Research Foundation, pp. 95-98.