

**Affidavit of Ming-Chih Hung, PH.D.**

COMES NOW Ming-Chih Hung, PH.D., being duly deposed and sworn, and states on his oath or affirmation all as follows:

1. My name is Ming-Chih Hung.
2. I am the same Ming-Chih Hung who gave a declaration executed Oct. 10, 2014, which is Exhibit 3 to the motion for post-conviction relief in *Mann v. United States*, No. 4:14-CV-00614 (E.D. Ark.), a true and correct copy of which appears at Doc. No. 445-2 in the CM/ECF folder for *United States v. Mann*, No. 4:09-CR-00099-BSM (Apr. 22, 2015) (refiled with exhibits in color, as originally tendered to Court on paper October 20, 2014).
3. The foundational portions of my original declaration remain substantially the same except for the passage of time. In the year since I submitted my curriculum vitae as Exhibit A, I have published—with my coauthors—four additional peer-reviewed articles; made—with or without copresenters—six additional presentations at professional conferences; redeveloped and taught an additional online course entitled “Internet GIS [Geographic Information Systems]”; delivered an additional seven guest lectures in other professors’ courses; supervised—as committee chair or member—the completion of four additional master’s theses; participated in the supervision of examinations or advising for additional graduate students at earlier phases in their training; reviewed two additional manuscripts; served as a member of Northwest Missouri State University’s Extended Leadership Team; and represented it at the Missouri GIS Conference in Springfield, Missouri. From April 2014 through the present, I have chaired the Award Committee of the Remote Sensing Specialty Group, Association of American Geographers (AAG). This year I received a second Outstanding Reviewer award from the American Society of Civil Engineers.

4. In addition to reviewing the evidence listed in the original declaration, I have now examined and photographed the ammunition canisters used to demonstrate the effect on the surrounding earth if the canister introduced as Government Exhibit 99 had been buried flush with the surface of the earth in the woods off the cul-de-sac at the end of Galaxy Lane in London, Arkansas, and removed in the month of March.

5. I have reviewed the portion of the response to show cause by counsel for the respondent in No. 4:14-CV-00614 (Doc. No.483 in No. 4:09-CR-00099-BSM) that addresses the evidence I gave in the original declaration.

6. In the original declaration of October 10, 2014, I applied the established methods of photogrammetry to determine that the depth of the depression on the face of the earth that trial witnesses Mark Rinke and Ryan Kimbell said held an ammunition canister 14.5” high, 17.25-18.5” long, and approximately 7.5” wide (Doc. No. 483 at 521, ¶ 14) could have been no deeper than about ten inches. Doc. No. 445-2 at 4, ¶ 22.

7. The opinions, findings, and conclusions in this affidavit are given to a reasonable degree of scientific certainty.

**I. Respondent’s argument regarding the duct tape uses tape indoors from storage that is pressed down to its full design width, whereas the tape in the scene pictures was in a natural, relaxed condition conducive to distortion such as curving in on itself.**

8. One of the objects that I used as a reference in the initial declaration was a piece of duct tape that appears in several of the pictures that the respondent tendered to trial counsel in discovery and introduced into evidence in court. In Figure 1-1, this duct tape appears immediately next to a ruler bearing the words “ATF Laboratory BUREAU OF ALCOHOL, TOBACCO, FIREARMS AND EXPLOSIVES”.



**Figure 1-1. A photo showing where I measured the width of the duct tape (40mm rounds scene 012.jpg)**

9. In my original declaration, I compared the markings on the ruler in this picture with the size of the duct tape to determine that the width of the duct tape was 4.5 cm. I used the latter width to calculate other distances in the pictures where the tape appeared.

10. In its response, the respondent asserts that the width of the tape is 4.9 cm. It cites Respondent's Exhibit 4 at 14 (Affidavit of Oliver). In support of this figure, it introduced its Exhibit 8, which I reproduce here as Figure 1-2:



**Figure 1-2. A duplicate of Respondent's Exhibit 8**

11. From Respondent's Exhibit 8 (Figure 1-2), it is evident that the duct tape is being pressed down by a tape measure and stretched to its full design width. It further appears that the respondent's agents did this in an indoor environment (sometimes called "laboratory condition" or "maintained condition"). Presumably it had been stored indoors as opposed to being left in the same conditions in which the respondent and its collaborators gathered it—which would in fact have made it different in other ways than it was from the picture the respondent created of it for use in this action. This pressed and stretched condition in an indoor environment is not representative of the same tape's condition and configuration in the field at the time and place it was presented in the respondent's pictures of it as it was supposed to have been found in March 2009.

12. By contrast, Figure 1-1 shows the photo from which I extrapolated my measurement on the width of the duct tape. One can clearly see that *this* piece of duct tape is in a natural and relaxed condition; no one is pressing it to stretch it to its full design width. Such natural and relaxed field condition is different from the pressed and stretched lab condition. When left in the field and exposed to sun and precipitation, a piece of duct tape is amenable to distortions (such as curving in on itself) that frequently alter the width. Various of these distortions result in its taking up fewer pixels in a picture taken of the tape at the scene as opposed to the same or similar tape from a file where it has been pressed for years in a dry environment and then held down and stretched out with a measuring tape.

13. Compare the duct tape in Figure 1-2 (tendered as Respondent's Exhibit 8) with the tape in Figure 2-1 (based on Government Exhibit 98-E). In the latter figure, the short red line reflects the width of the duct tape. One can see again that the duct tape is in a natural and relaxed condition, the same as the one in Figure 1-1.

14. In determining sizes and distances in photogrammetry, one must use a reference object that is in the same condition as the target object, so that the environment interference can be minimized. Assuming the accuracy of the tape measure in Figure 1-2, the duct tape indoors, free from the elements, pressed down and stretched out as far as it will go, the width may be 4.9 cm. as the respondent contends. But when it had been placed outdoors and left there for an indeterminate time, it measured only 4.5 cm. in the field condition. My calculations are based on the factual width of the duct tape in the photographs the respondent tendered to trial counsel in discovery and introduced in evidence in court, measured using the authenticated ATF ruler in a picture from the respondent, rather than a piece that is denatured and distorted in the course of litigation.

**II. I did not select the bottom of the depression at random but by applying the reasoning, methodology, and standards of photogrammetry, which I have the qualifications to do, to the respondent's own photographs.**

15. In its response, the respondent argues that I selected the spot from which to calculate the actual depth of the depression in a "random" manner, and that "[n]o one knows where the bottom of the hole is". Doc. No. 483 at 37.

16. Figure 2-1 to this affidavit shows the image that I relied on to determine the depth of the depression in which the respondent claimed at trial Rinke and Kimbell found the canister buried.



**Figure 2-1. The image used to derive the depth of the hole in the first place (This image is a subset photo of “GE 98-E.jpg”.)**

17. Figure 2-1 is a subset of the image the respondent introduced at trial as Government 98-E. Trial Transcript (TT) at 940. It adduced testimony of the law enforcement

officer who took the picture that “these pictures fairly and accurately represent what [he] saw that day”, *i.e.*, March 3, 2009, when Rinke and Kimbell claimed to have “found” the canister within 1000 feet of Dr. Mann’s property.

18. I understand that the respondent now seeks to impeach the evidence it created, gathered, and presented at a trial resulting in a sentence of life imprisonment against Dr. Mann as a basis for any reliable opinion on the issues of the depth or age of the depression in the face of the earth in which it told the Court and jury the canister was buried. Doc. No. 483 at 36-37.

19. Far from being random, my specification of a given spot as the bottom of the “hole” on which the respondent relied as the location of Government Exhibit 99 prior to Mark Rinke’s claiming to have found it and—with Ryan Kimbell, removed it from the ground—was in the exercise of my professional judgment using methods in which I have been trained, which photogrammetrists employ every day for the measurement of sizes and distances.

20. In an effort to obviate any serious question concerning the accuracy of the determination of the depth of the depression, I have analyzed an additional image of the depression created by the respondent’s subdivision Bureau of Alcohol, Tobacco, Firearms & Explosives (ATF) itself, and produced to trial counsel in discovery, “40 mm round 003.jpg”. I include this image as Figure 2-2:



**Figure 2-2. A photo that clearly shows the bottom of the hole (40 mm rounds 003.jpg)**

21. In order to explain the relationship between the data in Figure 2-1 and Figure 2-2, I have marked several objects in distinctive colors in Figure 2-3:



**Figure 2-3. Marked photo (shown in Figure 2-1) with clearly identified objects**

22. Figure 2-3 shows a part of the photograph the respondent showed the Court and jury as Government Exhibit 98-E and that I have designed Figure 2-1, but with some objects marked with different lines, polygons, and with different colors. Figure 2-4 is the photograph the

respondent tendered in discovery (40 mm rounds 003.jpg) and that I have designated as Figure 2-2 is shown again, but with some objects marked with shapes in different colors. These colors and shapes will help me explain the visual relationship between Figure 2-1 and Figure 2-2. Once a visual relationship is established between these two photos, one can clearly see that my measurement is indeed to the bottom of the hole, not just a random location or top of leaves.



**Figure 2-4. Marked photo (shown in Figure 2-2) with clearly identified objects**

23. In Figure 2-3, there is a blue line marking a light colored stick poking out of the side of the hole. This light colored stick is also marked blue in figure 2-4.

24. In Figure 2-3, there is a green line marking a dark colored stick poking out of the side of the hole. This dark-colored stick is also marked green in figure 2-4.

25. In figure 2-3, there is a green outline (irregular and enclosed shape created with the freehand tool in the photo-editing program I used to mark these photographs from the

respondent) highlighting a pointy leaf. This same pointy leaf is also highlighted green in figure 2-4.

26. In Figure 2-3, there is an analogous blue outline highlighting a round-edge leaf. This same round-edge leaf is also highlighted in blue in Figure 2-4.

27. In Figure 2-3, there is an analogous red outline highlighting a leaf with holes on it. This same leaf with holes on it is also highlighted in red in Figure 4.

28. In Figure 2-3, there is an analogous yellow outline highlighting a leaf with two outings pointing to the right (the cyan dot). This same leaf is also highlighted in yellow in Figure 4, but because of different orientation, these two outings are now pointing to left (the same cyan dot).

29. In Figure 2-3, there is an analogous pink outline highlighting a leaf with a crack right in the middle. This same leaf with a crack right in the middle is also highlighted in pink in Figure 2-4.

30. In Figure 2-3, there is an analogous orange outline highlighting a leaf with a white part. This same leaf with a white part is also highlighted in orange in Figure 2-4.

31. There are many other leaves that can be identified on both figures to establish a visual relationship and comparison. These leaves suffice for the purpose of visualizing and realizing the effect of viewing the same things from different angles. Even it is difficult for one to see the bottom of the depression in Figure 2-1, it is clear on Figure 2-2 where the bottom of the depression is. With the visual relationship between Figure 2-1 and Figure 2-2, I will identify the location of my measurement precisely, which is indeed the bottom of the depression.

32. In Figure 2-4, there are two brown-shaded outlines. They indicated visible dirt, which is the bottom of the hole. Hence the respondent's statement that "[n]o one knows where the bottom of the hole is" is not correct. If one could identify the same dirt in Figure 2-3, one could do a clear measurement on the depth of the depression on that basis. But the actual objects that these brown shaded outlines highlight are not visible on Figure 2-3.

33. In preparing the initial declaration, I drew a long red line extending from the top of the hole to a location at the bottom of the hole, marked by a cyan dot in Figure 2-3. The location at the bottom of the hole is also highlighted as a cyan dot in Figure 2-4. Interpreting the photograph as I have been trained to do as part of my training and experience in photogrammetry, this cyan dot in Figure 2-4 is a rock on top of soil. My previous measurement is therefore from the top of the hole to the bottom of the hole. One may argue that my initial long red line does not really reach the rock. There is a difference of about 5 pixels between where my long red line ends and where the top of the rock is. One may also argue that there is a height for the rock, and my estimate on the height of the rock from Figure 2-1 is no higher than 15 pixels.

34. Making these hostile assumptions in an abundance of caution, there is at most a difference of 20 pixels between where my long red line ends and where the bottom of the hole is. By my previous calculation, each pixel is about 0.082 cm. Twenty pixels will therefore result in 1.64 cm, which is about 0.646 inch. Adding 0.646 inch to my previous finding (10.213 inches), the length of the long red line is 10.859 inches. It is elementary geometry that in a right triangle, the hypotenuse is always greater than either of the two sides (vertical side and horizontal side). The long red line is the hypotenuse; the depth of the hole is the vertical side. Making the foregoing hostile assumptions, the depth of the depression can still be no deeper than 10.859 inches.

35. My statement here regarding the depth of the hole (no deeper than 10.859 inches) is different from my previous measurement (no deeper than 10.213 inches) has resulted from renewed scrutiny in an effort to be as scientific as possible when faced with gross denials to the effect that the selection of a critical point was at “random” and no one knows something that is obvious from the evidence the respondent itself presented. It does not render “incorrect” the previous measurement.

36. For example, my second measurement includes the height of the rock in the depth of the depression, when one may argue *either* that the rock is on top of the soil (in this case, the

rock height is not part of the depression), *or* that the rock is embedded in the soil (in this case, there is no rock height above the floor of the depression). Whether the rock is part of the bottom of the depression or something extra inside the depression is therefore a metaphysical or existentialistic conundrum that we need not resolve: the ammunition canister could not have gotten as far into the earth as it would have had to in order for the top to have been flush with the ground as long as that rock was where it was.

37. To eliminate all doubts, my second measurement resolves all factual and methodological doubts in favor of making the depression deeper. Even when one does that, it makes a difference of at most 0.646 inches, barely more than half an inch when the object in question is 14.5 inches tall.

**III. Working from the height of the canister yields a depth of the depression of no more than 8.709 inches.**

38. Use of the duct tape as photographed at the scene was consistent with the reasoning, methodology, and standards of photogrammetry. In order to remove any doubt that the facts were necessarily different from the trial testimony about the position of the ammunition canister, I have performed a separate analysis using a different reference object. This analysis compares the canister itself, a standing stick, and the depression itself.

39. Figure 3-1 shows a photo (40 mm rounds 004.jpg) in which one can clearly see the canister and the depression in which Rinke and Kimbell testified they found it buried.



**Figure 3-1. A photograph from the respondent showing the canister together with the depression, but with the lower part of the canister blocked by the black plastic, and the bottom of the depression not visible in the same photograph**

40. As the respondent's witness Jason Smith took the picture, the lower part of the canister is blocked by the black plastic that was used to wrap the canister, and the bottom of the hole is not visible from this photograph.

41. Figure 3-2 is another photo (40 mm rounds 010.jpg) in which one can see the hole, including the bottom of the hole (as explained and applied in paragraphs 14-37).



**Figure 3-2. One photograph from the respondent showing the bottom of the depression**

42. As the respondent's witness took the picture, black plastic material blocks the lower part of the canister in Figure 3-1. From a substantially identical canister (shown in Figure 3-3), one can still measure what I have called the "partial height" of the canister.

43. The partial height is identified in Figure 3-4 by the blue line. It is the distance between the bottom of opening ring (the extra metal piece at the opening of the canister, as shown in Figure 3-5) and the projected intersection of the front side and the diagonal line on the side (as shown in Figure 3-6). The partial height is smaller than the actual height of the canister. The partial height is used in this document for measurement purpose only because it can be precisely projected and measured.



**Figure 3-3. A substantially identical canister which partial height can be measured**



**Figure 3-4. Marks on the photograph to enable measurement on the canister and the reference object**



**Figure 3-5. Photograph showing the top of the partial height and the bottom of opening ring (the extra metal piece at the opening of the canister)**



**Figure 3-6. Photograph showing the bottom of the partial height, and the projected intersection of the front side and the diagonal line on the side**

44. One can clearly identify and measure the partial height on an actual canister, and in the photos. It is 13.25 inches on an actual canister, and 600 pixels on Figure 3-4.

45. In Figure 3-4, there is an additional reference object, a standing stick right next to the hole, as highlighted by the green line. This reference object is 281 pixels, or only 46.83% of the partial height of the canister.

46. In Figure 3-7, I have highlighted in green the same reference object (the standing stick) from Figure 3-4. Figure 3-7 is a subset of Figure 3-2 to have a better view.



**Figure 3-7. Marks on the photograph to enable measurement on the depth of the depression**

47. In Figure 3-7, one can clearly see the bottom of the hole, as well as the new reference object. In Figure 3-7, the reference object is measured 171 pixels. To establish by an additional exercise in photogrammetry the depth of the depression, I have drawn a line from the top of the depression to the bottom of it, the blue line in Figure 3-7.

48. In a right triangle, the hypotenuse is always greater than either of the two sides (vertical side and horizontal side). The blue line is the hypotenuse, while the depth of the hole is the vertical side. Therefore the depth of the hole cannot be larger than the blue line. The blue line is 240 pixels, or 140.35% of the reference object in Figure 3-7. Because the reference object is only 46.83% of the partial height (as illustrated in Figure 3-4), the blue line is therefore only 65.73% of the partial height (140.35% times 46.83%). {  $140.35\% * 46.83\% = 65.73\%$  }

49. It is my conclusion from the photographs and calculations presented in this section of this affidavit that the depth of the depression cannot be larger than 65.73% of the partial height of the canister.

50. The partial height of the canister is 13.25 inches.

51. Using the additional reference object in an exhibit that the respondent introduced as evidence to the Court and jury, therefore, the depth of the depression can be no more than 13.25 inches multiplied by 65.73%, that is, 8.709 inches. {  $13.25 * 0.6573 = 8.709$  }

52. This is shallower than the sizes that the use of the duct tape yielded, or than the next alternative reference object yields.

53. It is not surprising that the use of an alternative reference object yields a shallowness of an inch and a fraction less than the other reference objects I have used. Photogrammetry proceeds by the scientific analysis of photographs. A photograph is generally a two-dimensional representation of a three-dimensional physical reality. When the three-dimensional environment is reduced to a two-dimensional representation, there is some information loss, including the perception of depth or distance between our eyes and the observed objects. The accuracy of distance measurements depends on many factors, such as viewing angle, orientation, reference object, target object, and others.

#### **IV. Working from the ATF bottle yields a depth of 10.65 inches.**

54. Respondent's attack on the depth of the depression measured by reference to the duct tape in its pictures fails to take into account the fact that the duct tape in the respondent's scene pictures was in the field and therefore curved in, whereas its Exhibit 8 in this action was pressed down and spread out after years of storage indoors and perhaps even pressed for these years. In order to remove any doubt that may be lingering in light of the photogrammetric analysis, I performed an additional test using a different reference object: a bottle the ATF had apparently placed in the hole with a ruler.

55. Figure 4-1 is a photograph (40 mm rounds 008.jpg) in which one can clearly see a bottle placed at the bottom of the hole, with a ruler as a reference object. In this figure, one can measure the width of the bottle cap, but it is difficult to measure the height of the bottle because the ruler is blocking half of the bottle:



**Figure 4-1. A photo shows the hole, a bottle, and a ruler.**

56. Figure 4-2 is a photograph (40 mm rounds 010.jpg) showing the side of the bottle (in the middle of the picture, right next to a pole), which serves as a reference to estimate the size of the bottle cap and the size of the bottle body:



**Figure 4-2. A photograph shows a side of the bottle (in the middle right next to a pole).**

57. A subset of the photograph (40 mm rounds 010.jpg) focusing on the bottle is shown in Figure 4-3, in which one can clearly see the bottle, and one may also be able to measure the bottle cap height, the bottle cap width, and the bottle body height with suitable reference.



**Figure 4-3. A subset of Figure 4-2, where one can clearly see the side of the bottle.**

58. To help explain the procedure to measure the bottle, Figure 4-4 shows some marks to identify important dimensions of the bottle.



**Figure 4-4. Measuring the dimension of the bottle (bottle cap height, bottle cap width, bottle body height)**

59. The bottle cap height is identified by a green line, bottle cap width by red line, and bottle body height by blue line. The green line measures 26 pixels, red line 80 pixels, and blue line 131 pixels. Therefore, bottle cap height:bottle cap width:bottle body height ratio is 26:80:131.

60. Figure 4-5 shows the same photograph as in Figure 4-1, but with lines to help interpret and measure bottle dimensions, and therefore depth of the depression.



**Figure 4-5. Marks on photograph to help measure depths and distances**

61. All of these lines are placed at a particular angle, either horizontal (parallel to the orientation of the ruler) or vertical (parallel to the orientation of the upward direction of the bottle) to minimize effects brought up by different viewing angles and orientations.

62. According to the ATF (unless it wishes to disown the ruler or admit that it is not actually a six-inch ruler), the ruler is 6 inches long, which occupies 589 pixels. This is our reference for horizontal measurements. The horizontal green line identifies the width of the bottle cap, and it measures 155 pixels. The bottle cap is to the length of the ruler as 155 is to 589. Unless the ATF wishes to disown the ruler or say it was a trick, the ruler is six inches long. Therefore, the bottle cap width is 6 times the quantity 155 divided by 589, which equals 1.58 inches. {  $6 \left( \frac{155}{589} \right) = 1.58$  }

63. As we have seen from examining Figure 4-4, the ratio between cap height, cap width, and body height is 26:80:131. The bottle cap height is therefore 1.58 inches times the quantity 26 divided by 80, which equals 0.51 inches.  $\{ 1.58 \left( \frac{26}{80} \right) = 0.51 \}$  The height of the bottle body is 1.58 inches times the quantity 131 divided by 80, which equals 2.59 inches.  $\{ 1.58 \left( \frac{131}{80} \right) = 2.59 \}$  Therefore, the dimensions of the bottle are 0.51 inches:1.58 inches:2.59 inches (bottle cap height, bottle cap width, bottle body height). The vertical green line identifies the bottle cap height, which occupies 45 pixels. Therefore 45 pixels equals 0.51 inches. This is our reference for vertical measurements.

64. The blue line is a vertical line beginning from where the ruler rests on a side of the depression and extending upward. The cyan horizontal line identifies a line on an imagination surface plane, as if there were no depression at all and the ground were completely level. The left end of the cyan line ends at the top of the depression. The intersection of the cyan line and the blue line is at the top of the depression (or the surface), and it is vertically on top of the ruler. This is the depth of the point where ruler rests. This section of blue line (from bottom of the blue line to the intersection with the cyan line) is measured 727 pixels. According to our vertical reference (the bottle cap height, 45 pixels equal to 0.51 inches), the depth of the ruler is calculated as 0.51 times the quantity 727 divided by 45. That equals 8.24 inches.  $\{ 0.51 \left( \frac{727}{45} \right) = 8.24 \}$

65. The ruler touches the bottle near the top of the bottle body, but not quite exactly at the top. The pink vertical line (found at where the ruler touches the bottle) identifies the difference between the top of the bottle body and where ruler touches the bottle body. This pink line measures 16 pixels, therefore it is 0.51 times the quantity 16 divided by 45. That is 0.18 inches.  $\{ 0.51 \left( \frac{16}{45} \right) = 0.18 \}$

66. As calculated earlier, the bottle body height is 2.59 inches. All factors considered, the depth of the ruler is 8.24 inches, the height of the bottle (sitting on the bottom of the hole) is 2.59 inches, and there is a difference between the top of the bottle and the ruler (0.18

inches). From the top of the depression to the point where the bottle sits is 8.24 inches minus 0.18 inches plus 2.59 inches. The total is 10.65 inches. {  $8.24 - 0.18 + 2.59 = 10.65$  }

67. It is my conclusion from the photographs and calculations presented in this section of the affidavit—working from the ATF bottle and ruler as the reference objects—that the depth of the hole is around 10.65 inches.

68. From publicly filed documents in this case, see PCR/Habeas Exhibit 5 (specifically Doc. No. 395, pages 125-130), I am aware that Dr. Mann has sought the dimensions of the bottle from the ATF under the Freedom of Information Act. Because neither it nor any other agent or agency of the respondent chose to comply with this request, I have used photogrammetry to calculate the dimensions of the bottle. I have done so with the benefit of my own years of training and experience in the process, as well as the work over preceding years that other scientists have devoted to developing the process. The process has not been challenged in this action; from judicial opinions I have seen, I know that the respondent uses photogrammetry in court itself. Notwithstanding its own use of the same science and the repeated judicial acceptance of it, the fact remains that the numbers are less accurate than hands-on measurement of the bottle itself either by me or by the ATF as reflected by a sworn statement from the ATF. Although the methods I have used are sound, the conclusions of this application would have been more accurate with respect to the size of the bottle if the respondent had answered Dr. Mann's questions about the size of the bottle.

69. I performed three different methods to measure the size of the depression (duct-tape method, canister/stick method, and bottle method) from the photographs that the respondent created and or introduced in court or both. In doing so, I followed the reasoning, methodology, and standards of photogrammetry reflected in years of training and experience on my part. Though there are differences between the resultant depths, it is not uncommon given the fact that when those photographs were taken, the choice of reference objects was constrained by the party that now seeks to discredit the results of my work.

