OSAC RESEARCH NEEDS ASSESSMENT FORM

Title of research need:	Development of Quantitative Assessment and Evaluation of Error Rates in Physical Fit Determinations of Trace Materials

Keyword(s):	Trace evidence, interpretation, physical fit, fracture fit, fracture match

Submitting subcommittee(s):	Trace Materials	**Date Approved:**	6/12/2025

Background Information:

1. Does this research need address a gap(s) in a current or planned standard? (ex.: Field identification system for on scene opioid detection and confirmation)

Trace materials, such as fabric, tape, paint, plastic, or glass can be broken, torn, cut, or otherwise separated during different criminal activities such as homicides, kidnappings, and sexual assaults. Likewise, plastic and metal parts that hold the automotive paint can be bent during a crash or hit and run, lifting fragments of paint from the original substrate. In these events, it is possible that the fragments transferred during the violent activity physically align with the original source to form one continuous piece. If sufficient individual characteristics are observed within the corresponding edges and surfaces of the questioned evidence and the known source, the forensic examiner can conclude there is a physical fit among the items .

It is hypothesized that random physical fits of trace materials are improbable, and therefore when found they are considered the highest degree of association that can be determined in a forensic examination.

There have been few experimental studies that have evaluated the error rates in such determinations, and there is an interest in the field to further explore ways to support the empirical observations involved in making physical fit determinations. Moreover, the conclusion of a fit between edges relies on the examiner's opinion to identify those distinctive features.

It is crucial to explore mechanisms to qualify and quantify physical fit features, and develop standardized methods to evaluate the quality of a fit and the error rates associated with such conclusions.

The factors affecting the evaluation and interpretation of the significance and meaning of observed features are anticipated to vary by the composition of each material (e.g., tape, fabrics, glass, plastic), and as a result, independent validation studies are recommended for each trace subdiscipline as appropriate.

The results of this research are required to explore strategies to effectively qualify and quantify distinctive features in physical fit examinations and to serve as a scientific foundation to develop standard methods that complement and substantiate the examiner's opinions.

2. Are you aware of any ongoing research that may address this research need that has not yet been published (e.g., research presented in conference proceedings, studies that you or a colleague have participated in but have yet to be published)?

Trejos group at WVU

3. Key bibliographic references relating to this research need: (ex.: Toll, L., Standifer, K. M., Massotte, D., eds. (2019). Current Topics in Opioid Research. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-88963-180-3)

1. ASTM C1256. Standard Practice for Interpreting Glass Fracture Surface Features.
2. ASTM E2288-09. Standard Guide for Physical Match of Paper Cuts, Tears, and Perforations in Forensic Document Examinations (Withdrawn 2018).
3. Baca AC, Thornton JI, Tulleners FA. Determination of Fracture Patterns in Glass and Glassy Polymers. J Forensic Sci, Vol. 61, 2016, pp S92-101.
4. Bradley MJ, Keagy RL, Lowe PC, Rickenbach MP, Wright DM, LeBeau MA. A validation study for duct tape end matches, J Forensic Sci, Vol. 51, 2006, pp. 504-508.
5. Bradley MJ, Gauntt JM, Mehltretter AH, Lowe PC, Wright DM, A validation study for vinyl electrical tape end matches, J Forensic Sci, Vol. 56, 2011, pp. 606-611.
6. Brooks E. Statistical Assessment of the Significance of Fracture Fits in Trace Evidence. Masters Thesis, WVU Department of Forensic and Investigative Science, 2020. Available: https://researchrepository.wvu.edu/etd/7704. [Accessed 05/26/23].
7. Brooks E, Prusinowski M, Gross S, Trejos T. Forensic Physical Fits in the Trace Evidence Discipline: A Review, Forensic Science International, 313, 2020, https://doi.org/10.1016/j.forsciint.2020.110349.
8. Claytor LK, Davis AL. Validation of Fracture Matching Through the Microscopic Examination of the fractured Surfaces of Hacksaw Blades, AFTE Journal, Vol. 42(4), 2010, pp. 323-334.
9. Christensen AM, Sylvester AD. Physical Matches of Bone, Shell and Tooth Fragments: A Validation Study. J Forensic Sci, Vol 53 (3), 2008, pp. 694-698.
10. Frechette, VD. Failure analysis of brittle materials. Advances in Ceramics, Vol 28, The American Ceramic Society, Westerville, Ohio, 1990.
11. Katterwe HW. Fracture Matching and Repetitive Experiments: A Contribution of Validation, AFTE Journal, Vol. 37 (3), 2005, pp. 229-241.
12. McKasson SC and Richards CA. Speaking as an Expert: A Guide for the Identification Sciences from the Laboratory to the Courtroom. Springfield, Illinois: Charles C Thomas Publisher, LTD. 1998. pp. 50-51, 124-144.
13. Orench JA. A Validation Study of Fracture Matching Metal Specimens Failed in Tension, AFTE Journal, vol. 37 (2), Spring 2005, pp. 142-149.
14. Prusinowski M. Assessing the reliability of physical end matching and chemical comparison of pressure sensitive tapes. Masters Thesis, WVU Department of Forensic and Investigative Science, 2019. Available: https://researchrepository.wvu.edu/etd/4026 [Accessed 05/26/23]
15. Prusinowski M, Andrews Z, Neumann C, Trejos T. Assessing significant factors that can influence physical fit examinations – physical fits of torn and cut duct tapes. Forensic Science International. Vol 34, 2023. https://doi.org/10.1016/j.forsciint.2023.111567.
16. Prusinowski M, Brooks E, Neumann C, Trejos T. Forensic interlaboratory evaluations of a systematic method for examining, documenting, and interpreting duct tape physical fits. Forensic Chemistry. 2023. 34: 100487. https://doi.org/10.1016/j.forc.2023.100487.
17. Prusinowski M, Brooks E, Trejos T. Development and validation of a systematic approach for the quantitative assessment of the quality of duct tape physical fits. Forensic Science International, 307, February 2020, https://doi.org/10.1016/j.forsciint.2019.110103.
18. Quinn GD. Fractography of ceramics and glasses. NIST Special Publication, 960-26e2, May 2016.
19. Spaulding J, Picconatto G. Characterization of fracture match associations with automated image processing. Forensic Science International. 2023. 342. Available at: 10.1016/j.forsciint.2022.111519.
20. Trejos T, Koch S, Mehltretter A. Scientific Foundations and Current State of Trace Evidence—a Review, Journal of Forensic Chemistry, 18, May 2020. https://doi.org/10.1016/j.forc.2020.100223.
21. Tsadok T, Wiesner S, Shor Y. Empirical proof of physical match: Systematic research with tensile machine. For Sci International, Vol. 166 (1), 2007, pp. 77-83.
22. Tulleners FA, Braun JV. The Statistical Evaluation of Torn and Cut Duct Tape Physical End Matching. NIJ Report Award Number 2009-DN-BX-K235. Available: https://www.ojp.gov/pdffiles1/nij/grants/235287.pdf [Accessed 05/26/23].

23. Van Hoven HA, Fraysier HD. The Matching of Automotive Paint Chips by Surface Striation Alignment, J Forensic Sci, Vol. 28 (2), 1983, pp. 463-67.
24. van Dijk CD, van Someren A, Visser R, Sjerps M. Evidential value of duct tape comparison using loopbreaking patterns. Forensic Sci International, 2022. Available at: 332:111178. doi: 10.1016/j.forsciint.2022.111178.
25. Von Bremen UG, Blunt L. Physical Comparison of Plastic Garbage Bags and Sandwich Bags, J Forensic Sci, Vol. 28 (3), 1983, pp. 644-654.
26. Yekuteli Y, Shor Y, Wiesner S, Tsach T. Physical Matching Verification. US Department of Justice Report TP-2558. Available: https://www.ojp.gov/pdffiles1/nij/grants/240639.pdf [Accessed 05/26/23].
27. Zugibe F, Costello J. The Jigsaw Puzzle Identification of a Hit and Run Automobile", J Forensic Sci, Vol. 31 (1), 1986, pp. 329-32.

4. Review the annual operational/research needs published by the National Institute of Justice (NIJ) at https://nij.ojp.gov/topics/articles/forensic-science-research-and-development-technology-working-group-operational#latest? Is your research need identified by NIJ?

Yes, this research need relates to several of the identified needs in the Impression and Pattern Evidence & Trace Evidence Sections.

5. In what ways would the research results improve current laboratory capabilities?

To date, there are limited standard methodologies and criteria for making decisions about the presence of a physical fit and the significance of such evidence. Therefore, it is anticipated that additional validation studies to determine the quality and quantity of physical fit features will assist with the development of standardized methods and offer scientific support for the interpretation of the evidence.

6. In what ways would the research results improve understanding of the scientific basis for the subcommittee(s)?

At the subcommittee level, these types of research would provide valuable support to the interpretation and report writing guidelines that are being developed for trace materials, particularly if we can integrate early in the process the feedback from practitioners, statisticians, the legal community and human resource experts. This research will also help different stakeholders within the OSAC to assess the utility and validity of these type examinations.

7. In what ways would the research results improve services to the criminal justice system?

The data derived from the research will provide a better understanding of the validity and error rates of physical fit determinations during the comparison of trace materials. Given the anticipated probative value of such examinations and the role that the evidence can play during investigative stages and during trials, it is of utmost relevance to narrow current gaps of knowledge in this field.

8. Status assessment (I, II, III, or IV): II

	Major gap in current knowledge	Minor gap in current knowledge
No or limited current research is being conducted	I	III

Existing current research is being conducted	II	IV

This research need has been identified by one or more subcommittees of OSAC and is being provided as an informational resource to the community.