

## Project Rationale & Goals

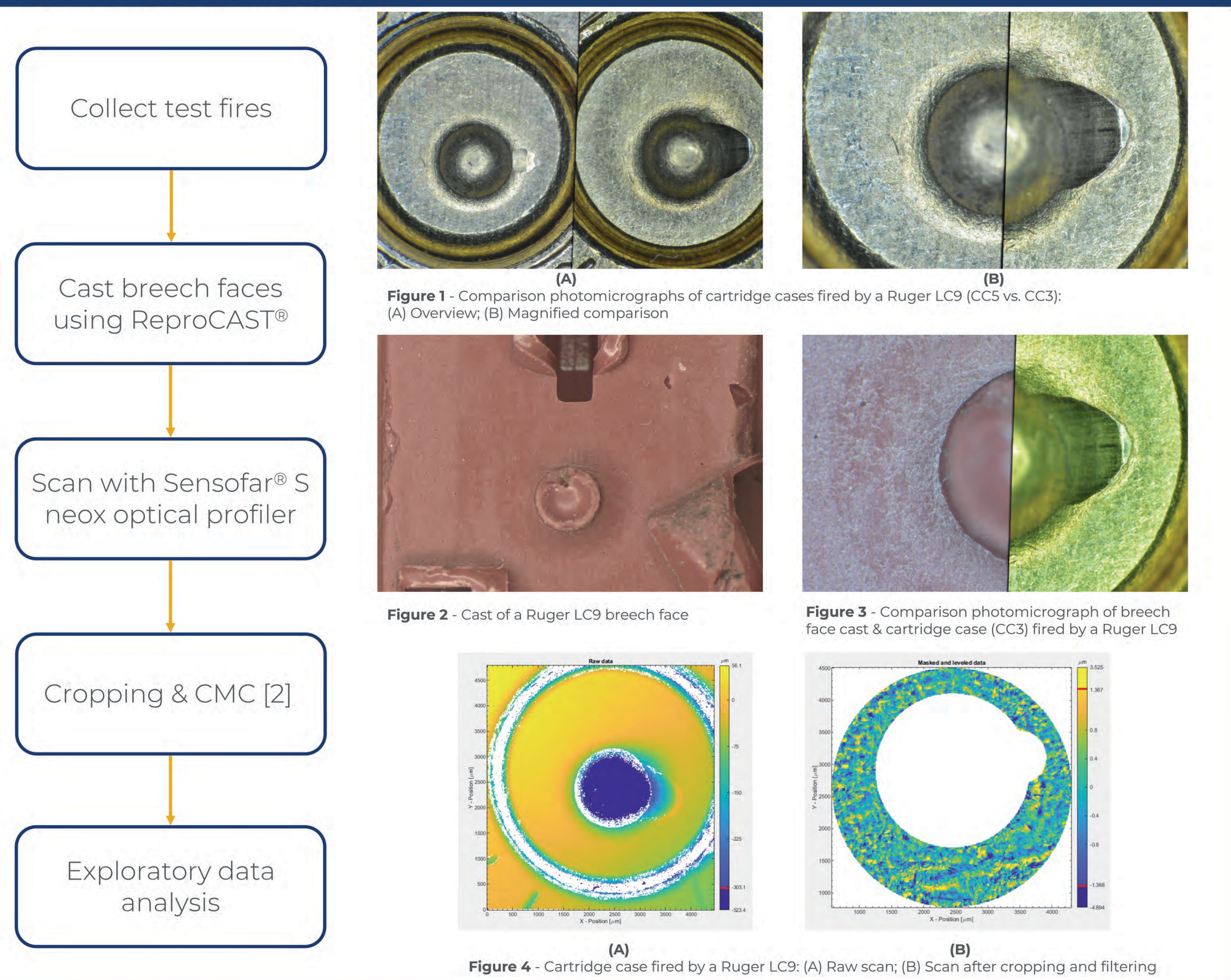
### Rationale

- Variation in the development of breach face impressions by different firearms is important to firearms examiners. However, common criticisms in the comparison of breach face impressions are related to the manufacturing processes and whether the marks produced on the breach face will result in sufficient agreement. [1]

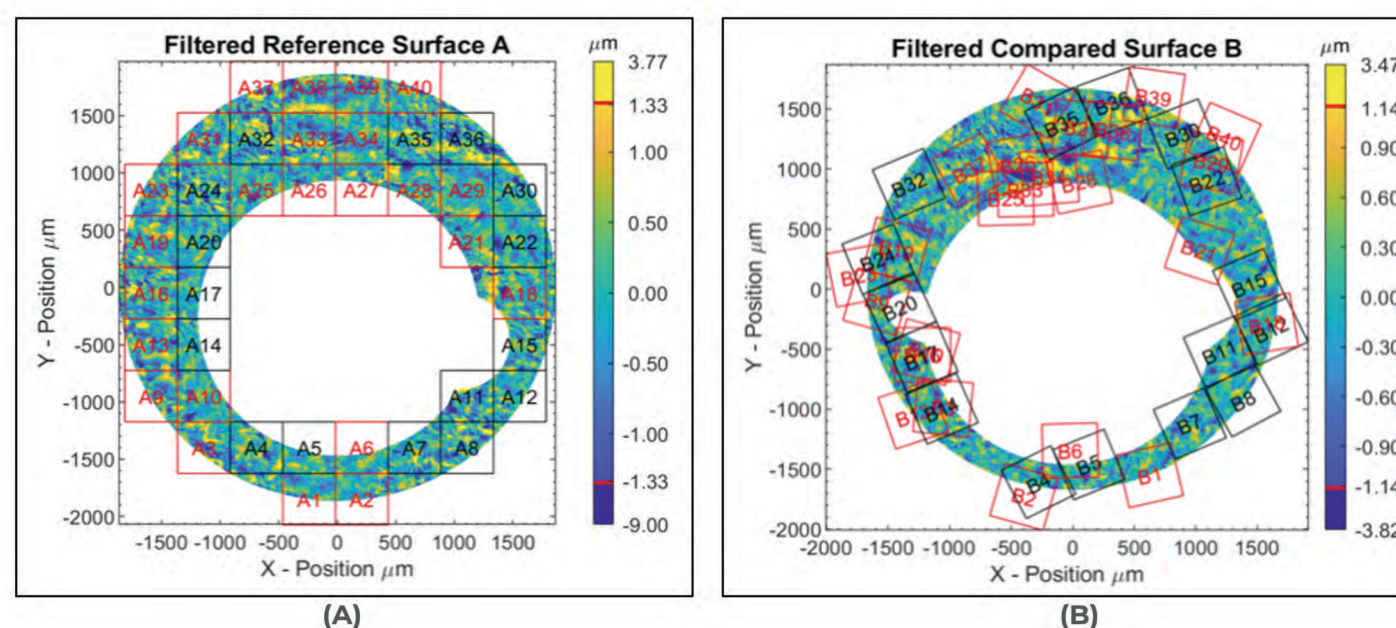
### Goals

- To assess the transfer of marks from the breach face of a firearm to the primer of a cartridge case by comparing breach face casts to cartridge cases using congruent matching cells (CMC) and areal cross correlation function (ACCF).
- Assessment of the variability on breach face impressions on cartridge cases fired by the same gun and the effect thereof on comparisons.

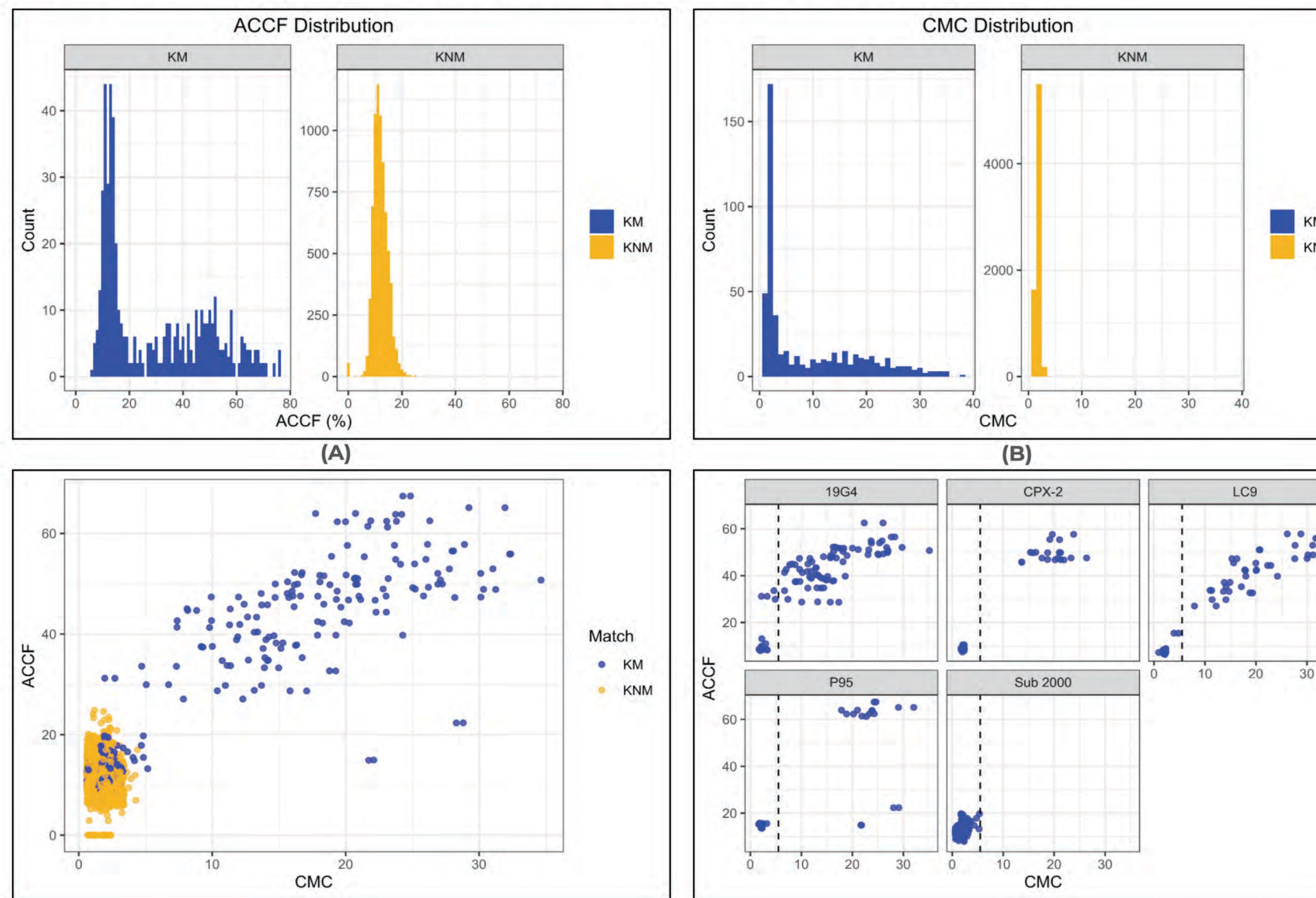
## Materials & Methods



## Results & Discussion



**Figure 5** - Correlation scheme using CMC algorithm: (A) Reference; (B) Compared



**Figure 6** - (A) ACCF distribution for all cartridge case correlations; (B) CMC distribution for all cartridge case comparisons; (C) ACCF versus CMC plot for all comparisons; (D) ACCF versus CMC plots of known matches for Glock 19 G4, SCCY CPX-2, Ruger LC9 (2 firearms), Ruger P95, and Keltec Sub 2000 comparisons

**Table 1** - CMC Results of Ruger LC9 (X32446) cartridge cases and cast

Reference	CMC	Compared					CAST
		1	2	3	4	5	
Reference	1		14	18	18	19	2
	2	17		8	11	11	2
	3	24	12		15	5	2
	4	20	11	14		20	2
	5	19	14	4	16		2
	CAST	2	2	2	2	2	

An example of the results produced by the CMC algorithm can be seen in **Figure 5**. Furthermore, **Table 1** illustrates the number of CMCs that resulted from bidirectional comparisons of cartridge cases and the corresponding breach face cast. In this subset data of a Ruger LC9, bidirectional comparison between cartridge case 3 and 5 showed relatively low CMCs. The existence of low CMCs between known matches (KM) was not entirely uncommon within the dataset. This would suggest the presence of variability in the transfer of breach face marks to cartridge cases that exceeds the tolerance of the 6 CMC minimum [2]. In general comparisons with casts yielded low CMCs, which has been attributed to the quality of the casting material. Similar to the Ruger LC9, most KM comparisons resulted in CMCs greater than the NIST criteria of 6 CMCs, whereas known non-matches (KNM) comparisons fell below that threshold.

**Figure 6** demonstrates various trends of ACCF and CMC for both KMs and KNMs (**Figures 6A** and **6B**). A receiver operating characteristic (ROC) curve was constructed for both CMC and ACCF. The areas under the curve (AUC) for CMC is 0.723 and ACCF is 0.715. These results suggest that when using CMC and ACCF as our similarity metrics, the accuracy on this dataset is over 70%. Throughout the whole dataset, all KNMs were confined to less than 6 CMC (**Figure 6C**). Though there were some false negatives, the majority are attributed to the Keltec Sub 2000, which needs further investigation. The other false negatives are related to cartridge cases compared to breach face casts. **Figure 6D** shows in more detail the breakdown of each firearm KM comparisons.

## Conclusions & Future Directions

### Conclusions

- CMC analysis shows that comparison of cartridge cases to breach face casts made from ReproCAST® material does not result in sufficient agreement between the marks captured in casts and transference marks captured on the primer.
- Variability of breach face impression development within a single firearm affects comparison between its cartridge cases, as shown by the range of CMC values correlated for individual firearms.

### Future Directions

- Expand the number of firearms in the study.
- Determine the cause of low CMCs in the breach face casts and the Keltec Sub 2000.
- Evaluate alternative casting materials such as MikroSil™ and MoldStar™.
- Develop a statistical model for data analysis.

## References & Acknowledgements

- Murdock, J.; Jones, J.A.; Della Penna, A.; Stone, R.; Newhouse, B.; Uchiyama, T.; Biasotti, A.; Warniment, D.; Warren, G.; Sibert, B.; et al. Theory Of Identification, Range Of Striae Comparison Reports And Modified Glossary Definitions - An AFTE Criteria For Identification Committee Report. *ATFE Journal* 1992, 24 (3), 336-340.
- Chen, Z.; Song, J.; Chu, W.; Soons, J. A.; Zhao, X. A Convergence Algorithm for Correlation of Breach Face Images Based on the Congruent Matching Cells (CMC) Method. *Forensic Science International* 2017, 280, 213-223.

We would like to thank the firearm and tool mark analysis team at the National Institute of Standards and Technology (NIST) for providing access to their tool mark research software.