Incendiary Flash Recognition and Scoring Software

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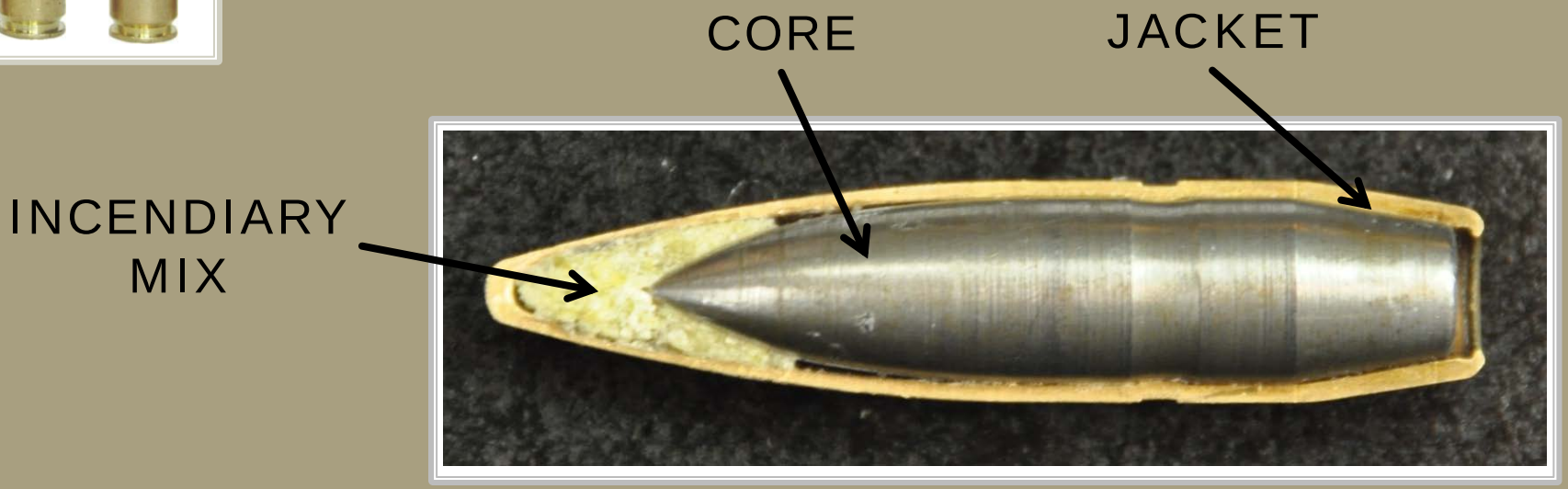
Cartridge Background

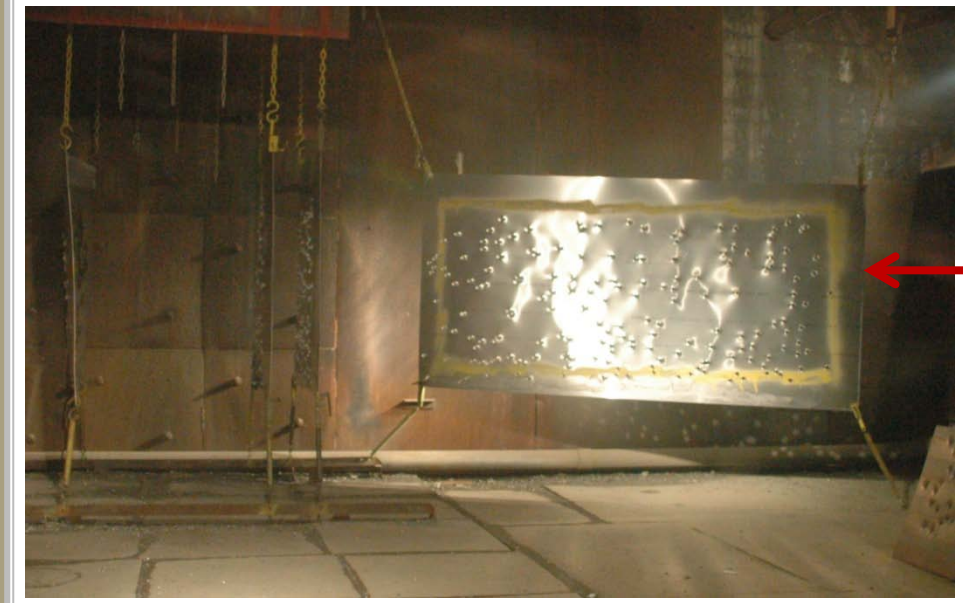
- Incendiary rounds contain an explosive mix in the tip of the bullet intended to detonate on impact with a target
- Effective for flammable targets, light armor, and marking



Test Background

Caliber .50 Incendiary Flash Testing

- Rounds are fired through a series of metal plates
- Photos of flash streaks are captured with a long shutter speed
- A specified number of images are recorded in order to determine if the lot of ammunition will pass or fail



Issues with Current Test

Subjective

- Images are scored by human operators based on visual standards
- Scores from different operators on the same image may vary

Qualitative

- Flash patterns show subtle variations that may not be easily seen
- The scoring visuals cannot depict every possible flash pattern

Inconsistent Image Quality

- Exposure, framing, and debris within the field of view of the camera have all presented problems

Inconsistent Image Quality

Typical Captured Image

Debris on window/lens

Image overexposed

Target framed improperly

Image Improvements

Ultraviolet Filter: Serves mainly as a lens protector

Infrared Filter: Blocks most frequencies of visible light and allows frequencies of infrared light to reach the camera sensor

Polarizing Filter: Reduces glare on reflective surfaces

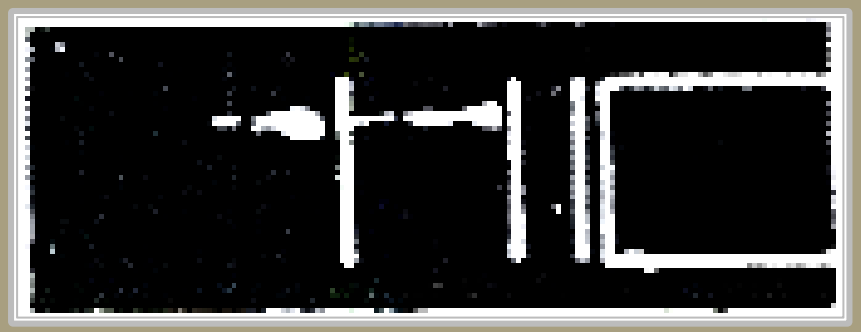
Ultraviolet

Ultraviolet, Infrared

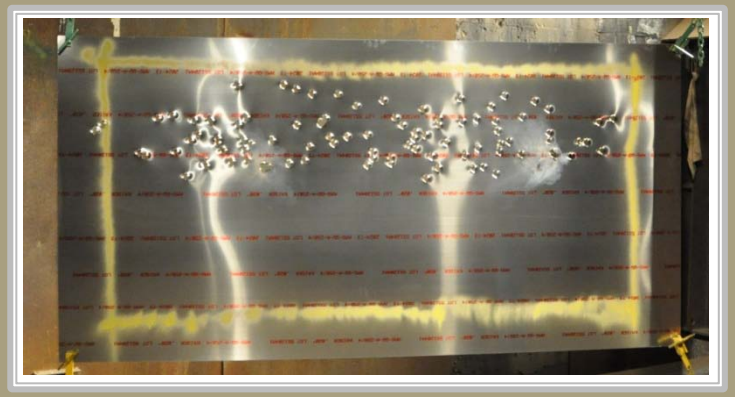
Ultraviolet, Polarizing

Test Improvements

Improvements to Scoring Standards: More representative of actual test



Lighting Improvements: Lights needed only for setup cause unnecessary glare on the plates – Setup and test lighting will be separated

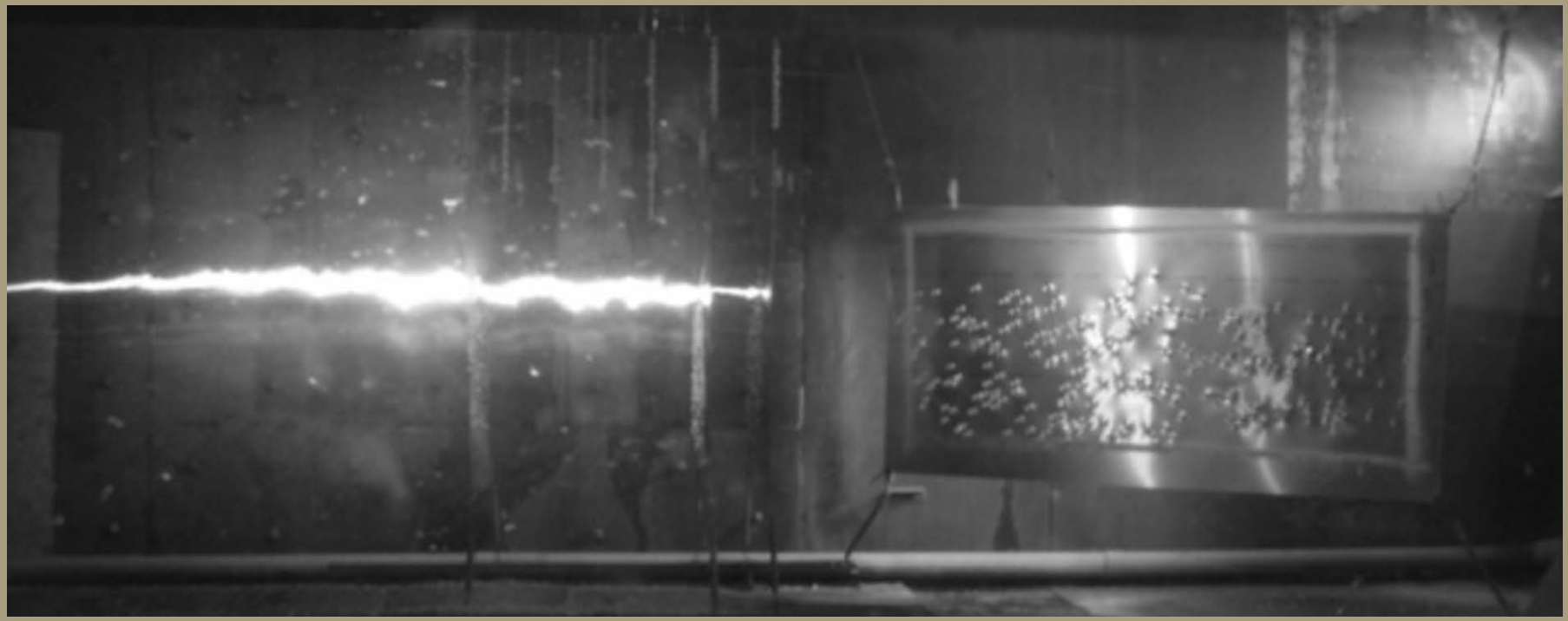


Framing and Background Detraction: Minimize complications from surroundings by framing the shot and painting the range with a non-reflective coating.

Overview of Scoring Software

- The software works to quantify an otherwise subjective incendiary flash image.
- The numerical values pulled from each image are compared to a database of standards in order to objectively score the image.

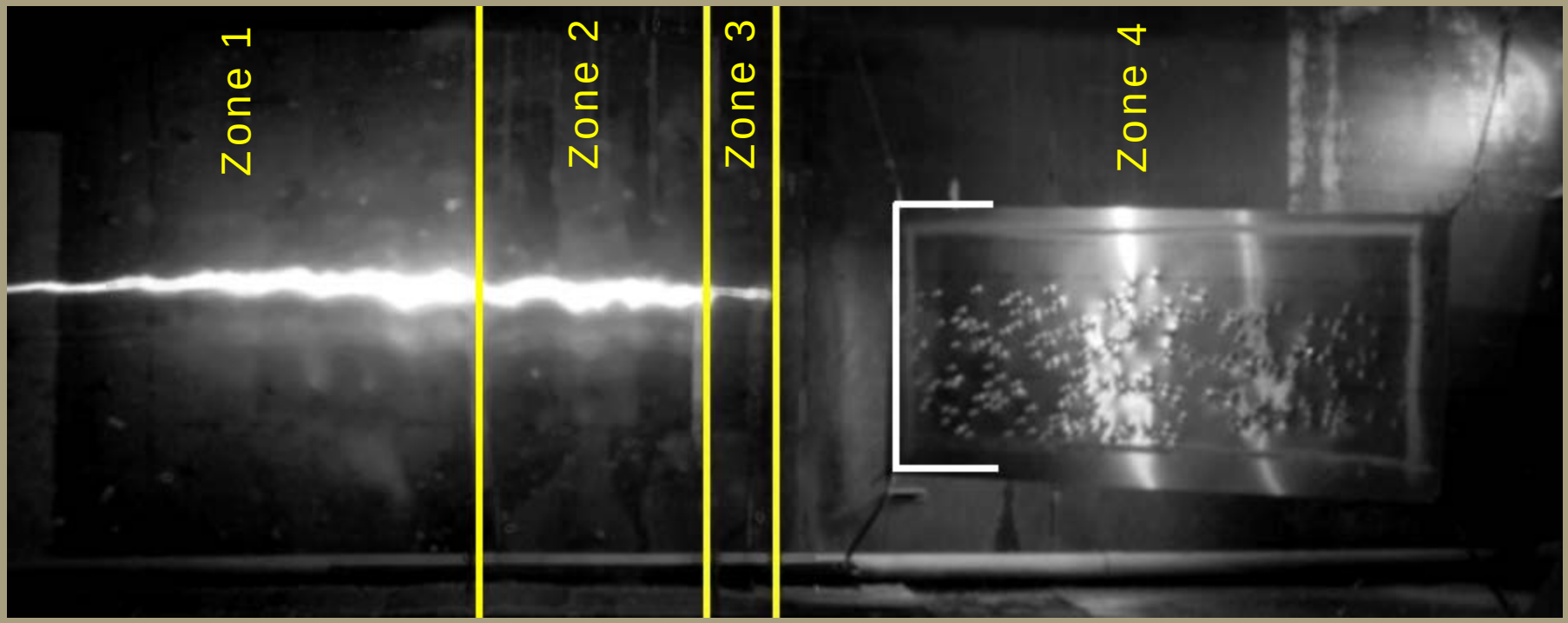
Original Test Image



Preprocessing

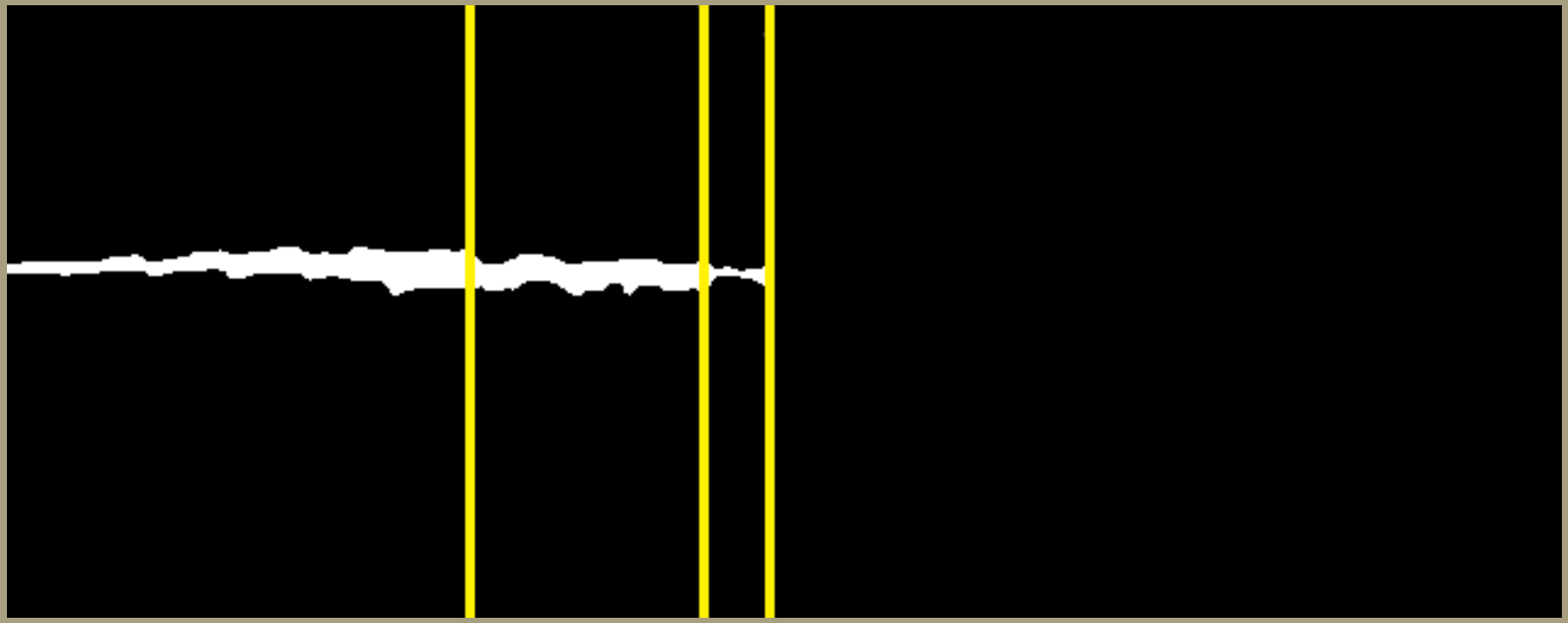
Linear color correction and noise reduction

Zoning



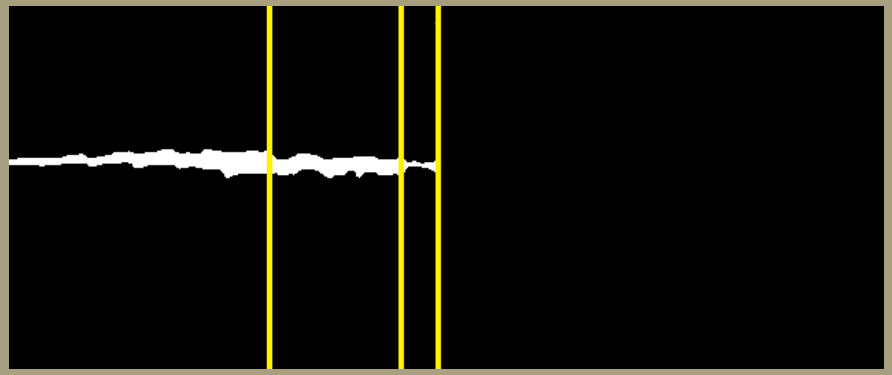
Segmentation

Binary thresholding, flood filling, and blobs processing



Flash Percentage Calculation

Note: Numerical values below are arbitrary



The percentage of white pixels in each zone is calculated relative to the total number of pixels in each zone

		Zone 1	Zone 2	Zone 3	Zone 4
Flash	Height	17	11	6	0
	Width	200	100	20	300
	Total	3400	1100	120	0
Background	Height	250	250	250	250
	Width	200	100	20	300
	Total	50000	25000	5000	75000
% Flash		**6.80%**	**4.40%**	**2.40%**	**0.00%**

Matching to Standards

Note: Scores and numerical values below are arbitrary

Standard Images				
Zone →	Z1	Z2	Z3	Z4
Score	↓	↓	↓	↓
A	0%	0%	0%	0%
B	0%	10%	15%	10%
C	10%	0%	0%	0%
D	5%	2%	0%	0%
E	8%	3%	0%	0%
F	1%	40%	7%	0%
G	0%	25%	0%	0%
H	3%	3%	4%	15%
I	5%	5%	4%	2%
J	16%	9%	0%	0%
K	10%	8%	0%	0%
L	**7%**	**5%**	**2%**	**0%**
M	12%	18%	15%	5%
N	4%	20%	10%	0%

Computed Offsets for a Test Image					
Zone →	Z1	Z2	Z3	Z4	Offsets
Test Image →	**6.80%**	**4.40%**	**2.40%**	**0.00%**	↓
A	6.80%	4.40%	2.40%	0.00%	13.60%
B	6.80%	5.60%	12.60%	10.00%	35.00%
C	3.20%	4.40%	2.40%	0.00%	10.00%
D	1.80%	2.40%	2.40%	0.00%	6.60%
E	1.20%	1.40%	2.40%	0.00%	5.00%
F	5.80%	35.60%	4.60%	0.00%	46.00%
G	6.80%	20.60%	2.40%	0.00%	29.80%
H	3.80%	1.40%	1.60%	15.00%	21.80%
I	1.80%	0.60%	1.60%	2.00%	6.00%
J	9.20%	4.60%	2.40%	0.00%	16.20%
K	3.20%	3.60%	2.40%	0.00%	9.20%
L	**0.20%**	**0.60%**	**0.40%**	**0.00%**	**1.20%**
M	5.20%	13.60%	12.60%	5.00%	36.40%
N	2.80%	15.60%	7.60%	0.00%	26.00%

Challenges

- Runtimes are currently longer than ideal
  - Automatically crop each photo
  - Eliminate excess pixels
- Software may mistake ambient light due to the flash (i.e. glow, plate reflection, etc.) as part of the flash itself
  - Experiment with different camera angles
  - Experiment with non-reflective coatings on metal plates

Points of Contact

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