



**Aerospace
Systems Division**
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Active Seismic Experiment
Accuracy of Velocity Measure-
ment

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The following is an analysis of the accuracy of redundant (Photographic) means of measuring grenade velocity as planned during ASE grenade firings at WSMR. The analysis was requested by NASA/MSC and the ASE PI at the ASE program review on 19 April 1967.

The expected RMS error as derived by the analysis is 1.2%.

Prepared by:

L. V. Liepa
L. V. Liepa

Approved by:

J. R. McDowell
J. R. McDowell



The redundant means of measuring initial velocities of all four grenades to be employed at WSMR will be high speed motion films. The nominal speed of the camera will be 1000 frames per second. Range Timing IRIG Type A will be recorded on film so that time will be known with an accuracy of 0.05%. The path of a grenade will be across two poles placed 5 feet apart, refer to Figure 1. The movie camera will be located 75 feet from the flight line and at right angle to it. Two velocity poles are two feet from the flight line in front and on the right hand side of the GLA.

In performing the velocity measurement, with a test setup as described above, following uncertainties can be identified:

1. Distance between two velocity poles.

Assuming a measurement of accuracy of ± 0.125 inches, error in 5 feet is $\pm 0.21\%$
2. Range Timing, at least $\pm 0.05\%$
3. Distortion by motion film camera.
No data can be obtained, but a reasonable estimate is $\pm 0.5\%$
4. Distortion by motion analyzer
Vanguard Instrument Corporation informs that their motion analyzer M-7/3/1 with S-13 case and 16X lens, which BxA has on order, has a total distortion of $\pm 0.5\%$
5. Human reading error.

With a 16 mm camera and a lens whose focal length is 4 inches, the image of two poles on film will be 0.27 inches apart. After magnification of 16 times on the analyzer the images of two poles will be 4.3 inches apart. Experience indicates that a position of the grenade can be plotted with an accuracy of ± 0.03 inches.



Hence reading accuracy can be calculated as

$$\frac{\pm 0.03}{4.3} \cos 45^\circ \times 100 = \pm 0.49\%$$

A grenade will travel between five poles at 45° to the horizontal line.

6. Parallax effect

Due to parallax a grenade will travel in fact a shorter distance than it appears on film. From geometry in Figure 1, this deviation is

$$5 \frac{2}{77} = 0.13 \text{ feet}$$

$$\text{or } \frac{0.13}{5} \times 100 = 2.6\%$$

Obviously, this is the largest deviation, however, it is not an error because it can be corrected for at the time of calculation of velocity.

After all uncertainties, 1 through 5, are added up the maximum error is 1.75%. However, an RMS error of 1.20% is more appropriate value because all errors are independent of each other.

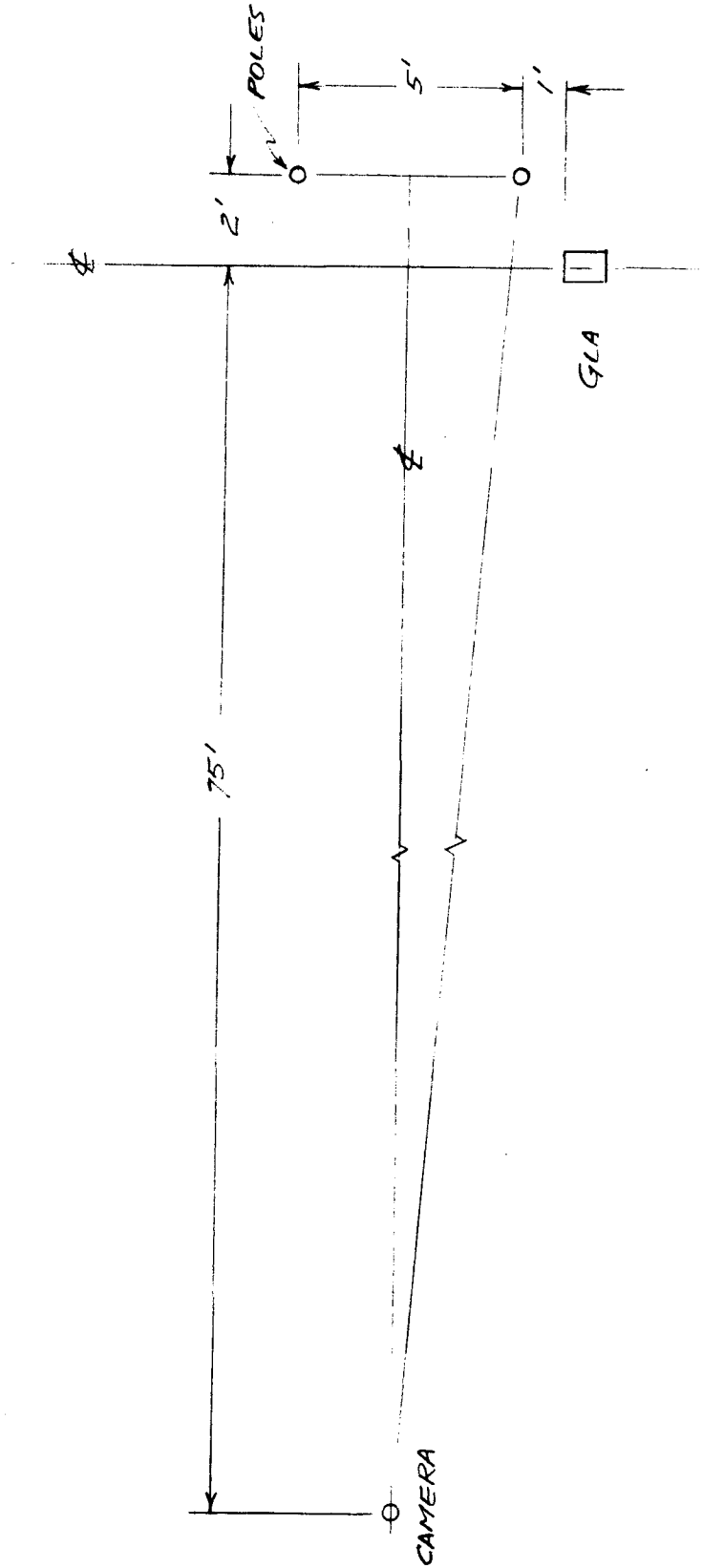


Figure 1 Location of Camera, GLA and Poles