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Improving Processes. Instilling Expertise.

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Electronics… the Art of Blasting turned Blasting Science

Sandy Tavelli / John Alkins

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The Search for a Better Way

- Detonator technology has evolved over the decades from goose quills filled with black powder to computer chips
- Explosives Engineering has evolved from what was once thought only as an “Art form”…into a science and engineering discipline.
- What was once only theoretical is now practical with evolution of products and timing precision.

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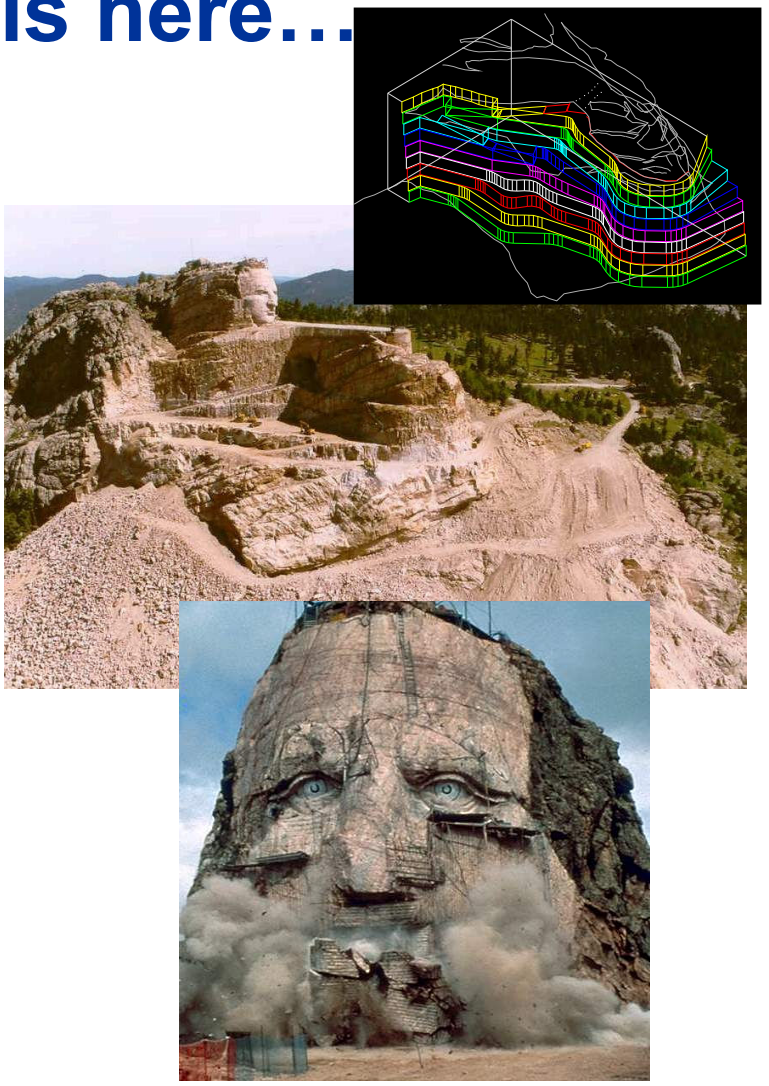
A Better Way is here…

- Blast designs that were once thought impossible are now quite easy to achieve.
- Explosive energy optimization is finally able to be controlled to the exact millisecond
- Explosive engineering can now be used to create “Art”..



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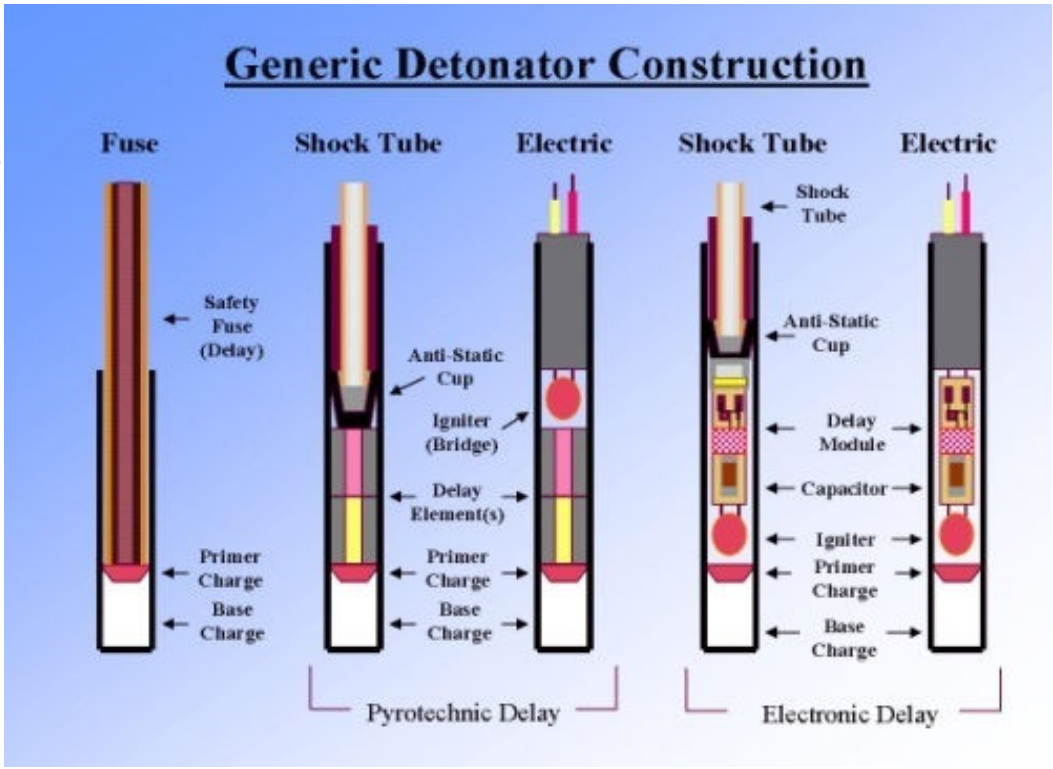
So What is an Electronic Detonator

- Three type of chemical delay detonators on left: Fuse Caps / Shock Tube / Electric Detonators
- Electronics utilize a stored energy device (capacitor) and Microchip (ASIC) for energy to run a timer
- **They are NOT electrics**
- **They are NOT non-electrics**



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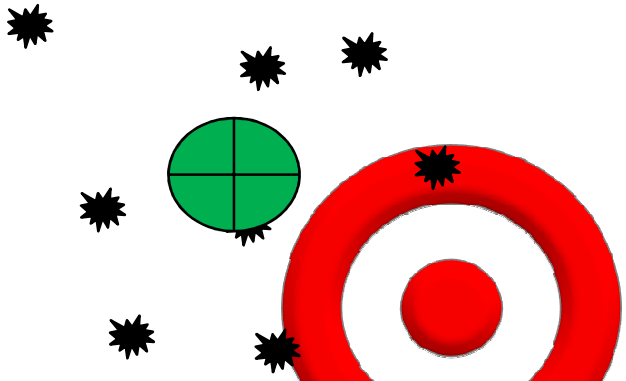
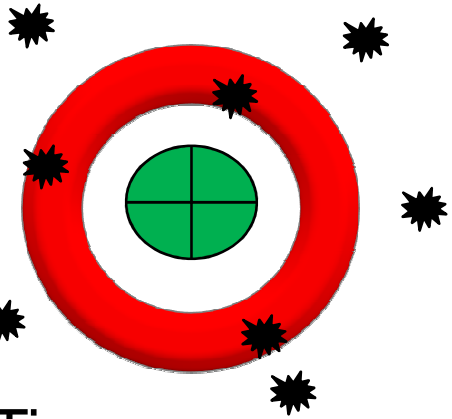
What is Precision and Accuracy

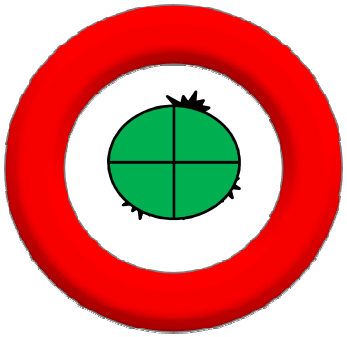


Not Accurate
Not Precise

Precise…
Not Accurate



Accurate…
Not Precise



Accurate…
AND Precise

Average Time

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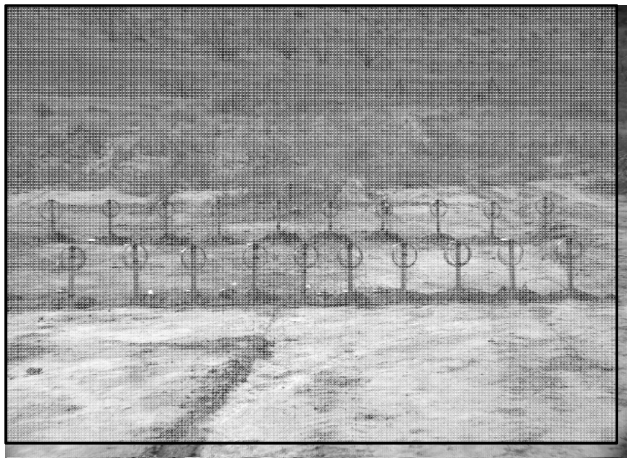
Pyrotechnic VS Electronics… Scatter

- All detonators have some level of "cap scatter"
- Electronics are measured in micro-seconds VS milliseconds
- Electronics virtually eliminates scatter < 1ms typical
- There has always been an issue of design VS actual timing
- Just how important that becomes…depends on products, designs, and blasting constraints
- Video of 900ms Pyros VS 1000ms Electronics

Please note: The pyrotechnics used in this demonstration include 900ms in hole caps coupled in some examples with fast surface delays to represent a worst case scenario.

Dyno Nobel manufactures an outstanding non-electric product range, which continues to service the bulk of our market requirements.



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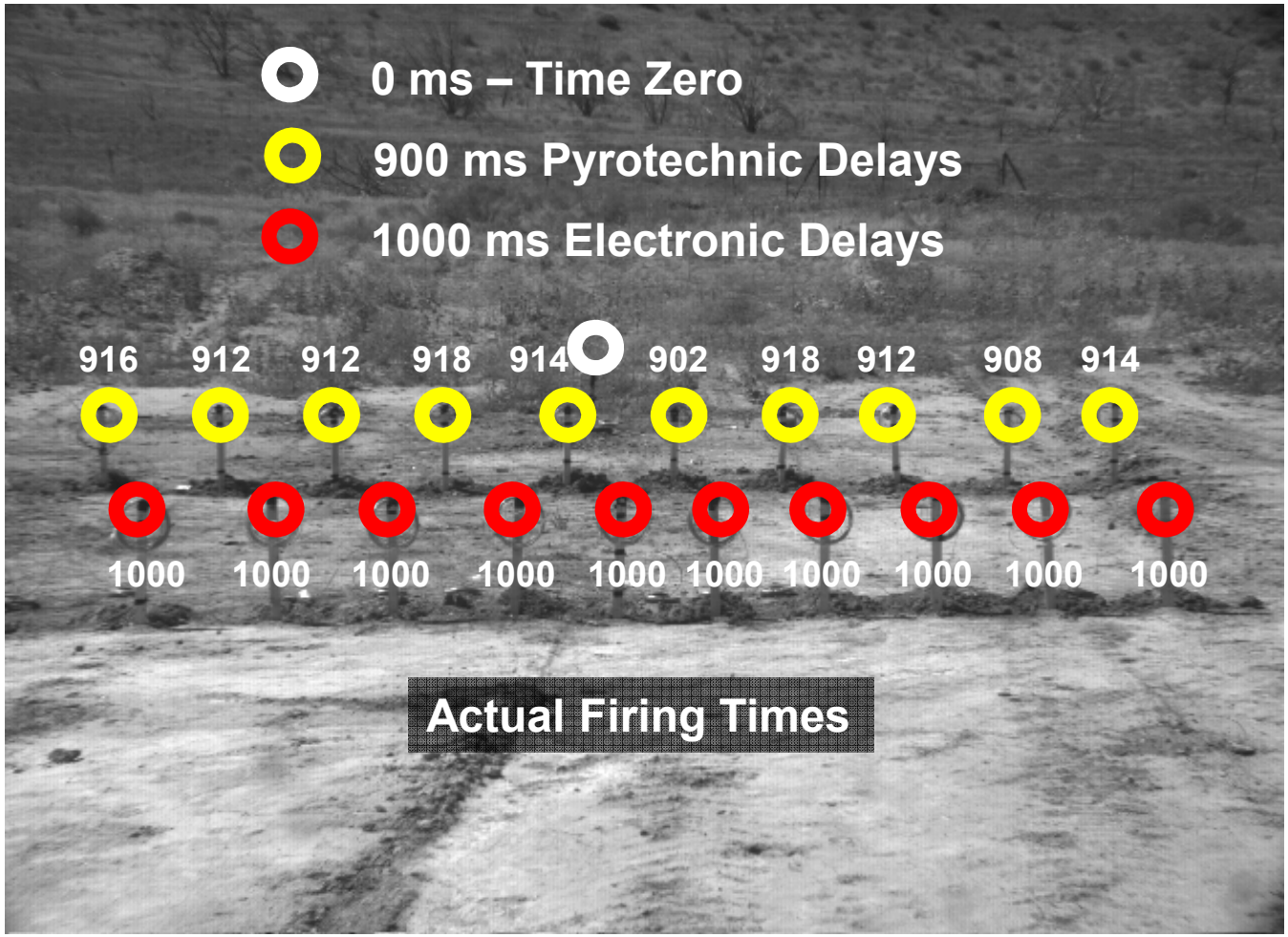
Pyrotechnic VS Electronics… Scatter



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8ms Rule… fact or fiction

- The 8ms Rule is a challenge meet if using pyrotechnics
- Not to mention not even applicable anymore if using electronics
- Today's modeling and field validation shows that 1 – 2 ms can be very critical for vibration control and frequency manipulation
- Electronics virtually eliminates concerns
- "On any given day" proper sequencing with pyrotechnics is dependent on lot selection, temps, statistical probability of the cap scatter

- tst2.avi

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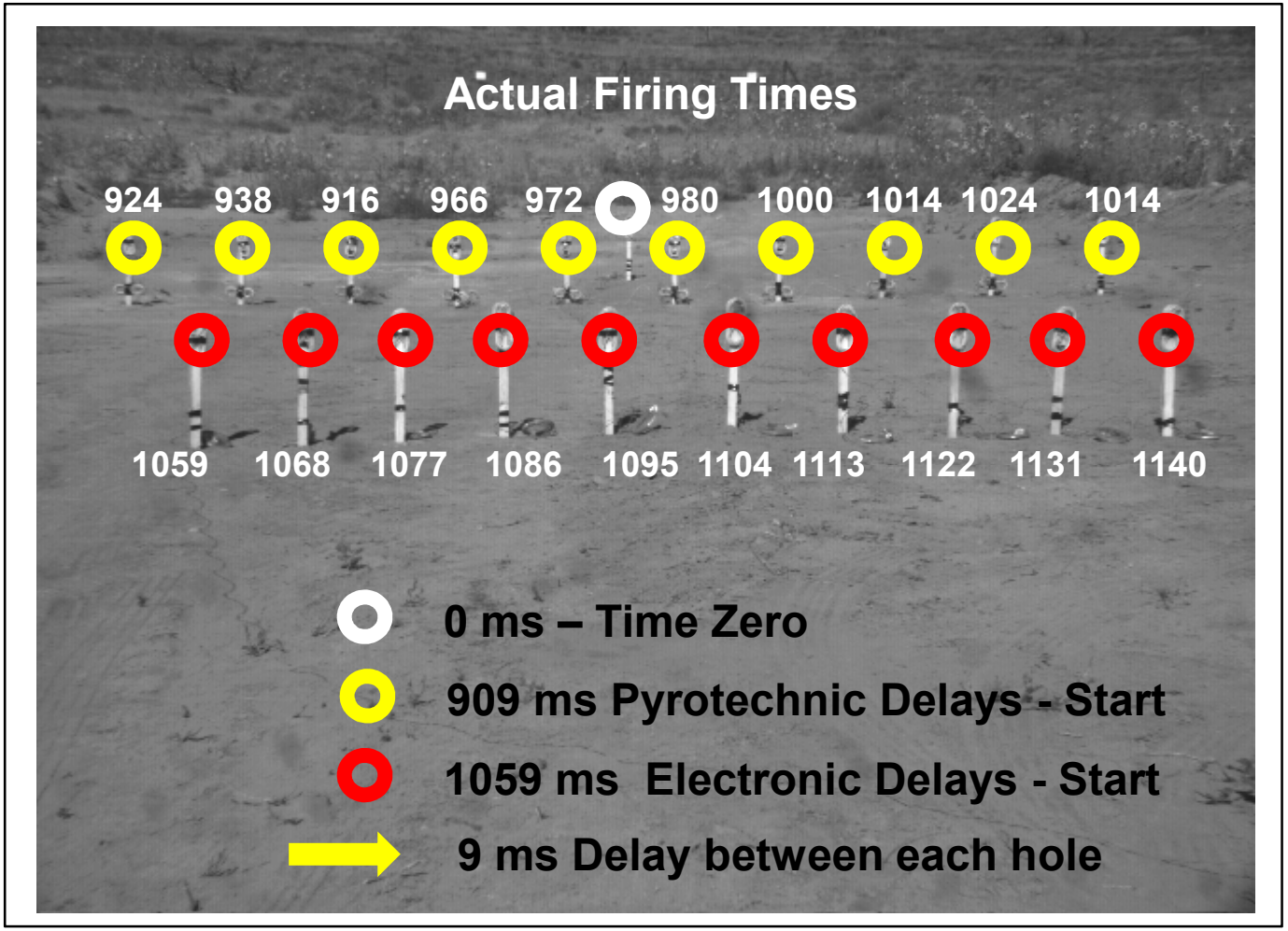
8ms Rule… fact or fiction



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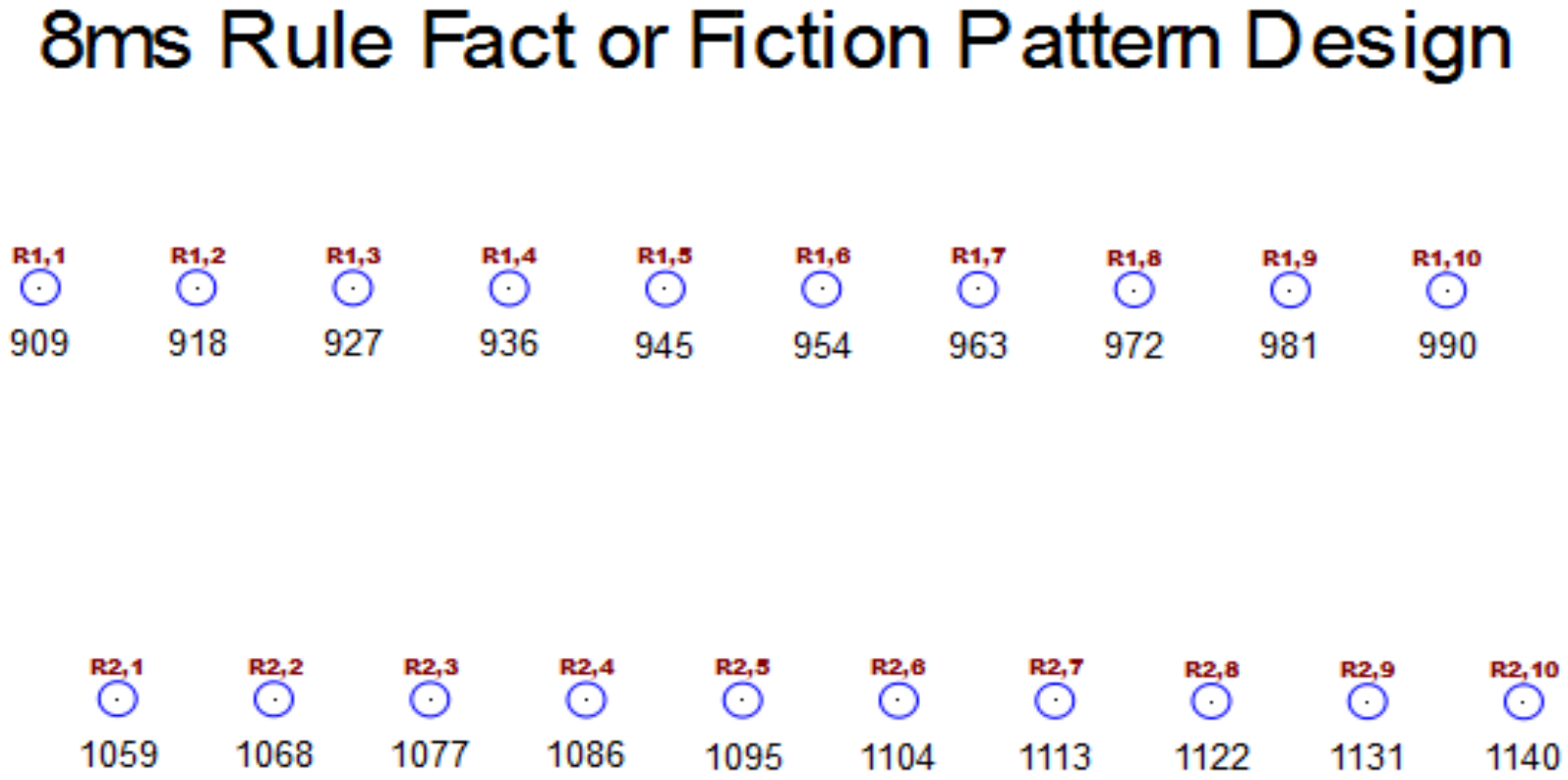
8ms Rule… fact or fiction



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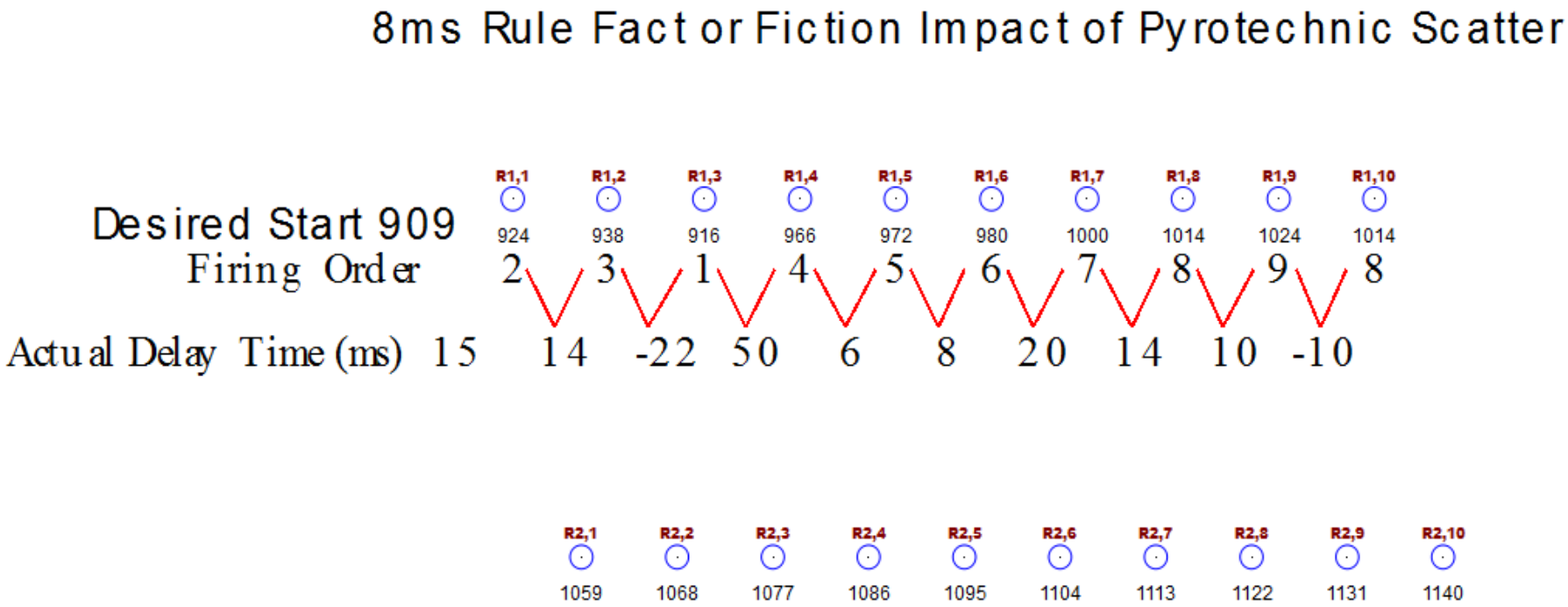
8ms Rule… fact or fiction



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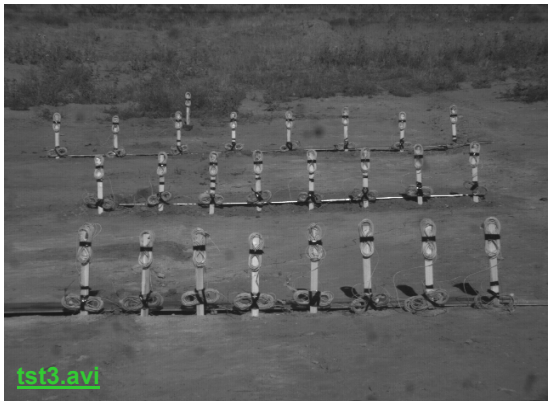
Putting in all together

- Cumulative effects of both surface delay detonators AND the In-hole detonators can have big effect on blast outcomes
- The test demonstration, 25ms between holes, 500ms in-hole and184ms between rows Pyro VS Electronic Initiation.
- Note the variability in within the pyro shot.
- What does cumulative error impact?

Vibration…..

- **Fragmentation…..**
- **Wall Stability…..**
- **etc.**



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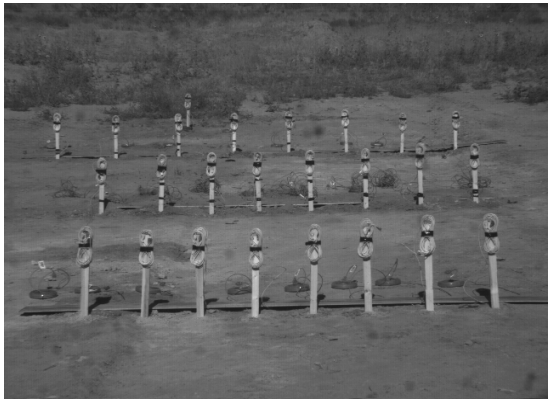

tst4.avi

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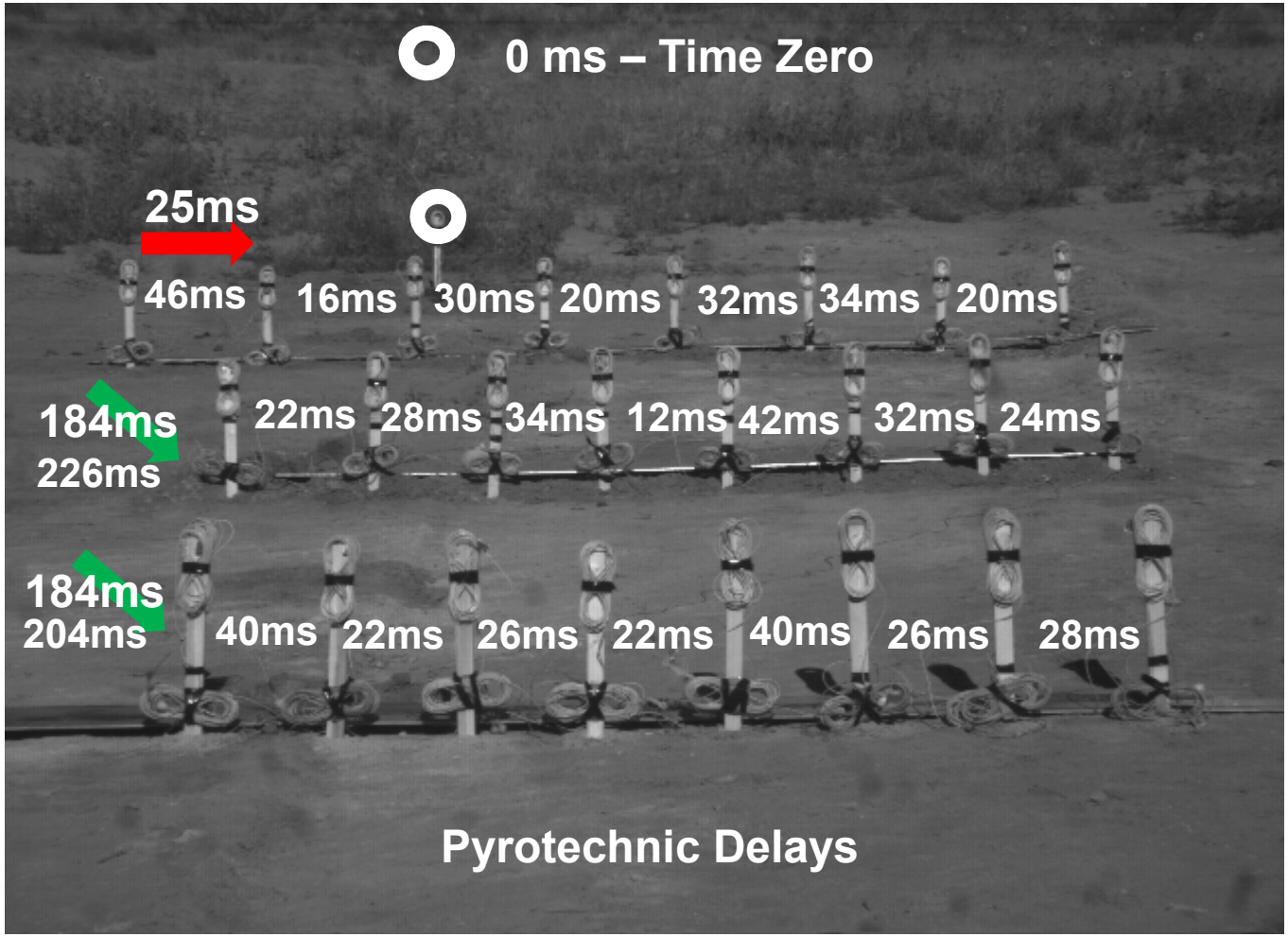
Putting in all together - Pyrotechnics



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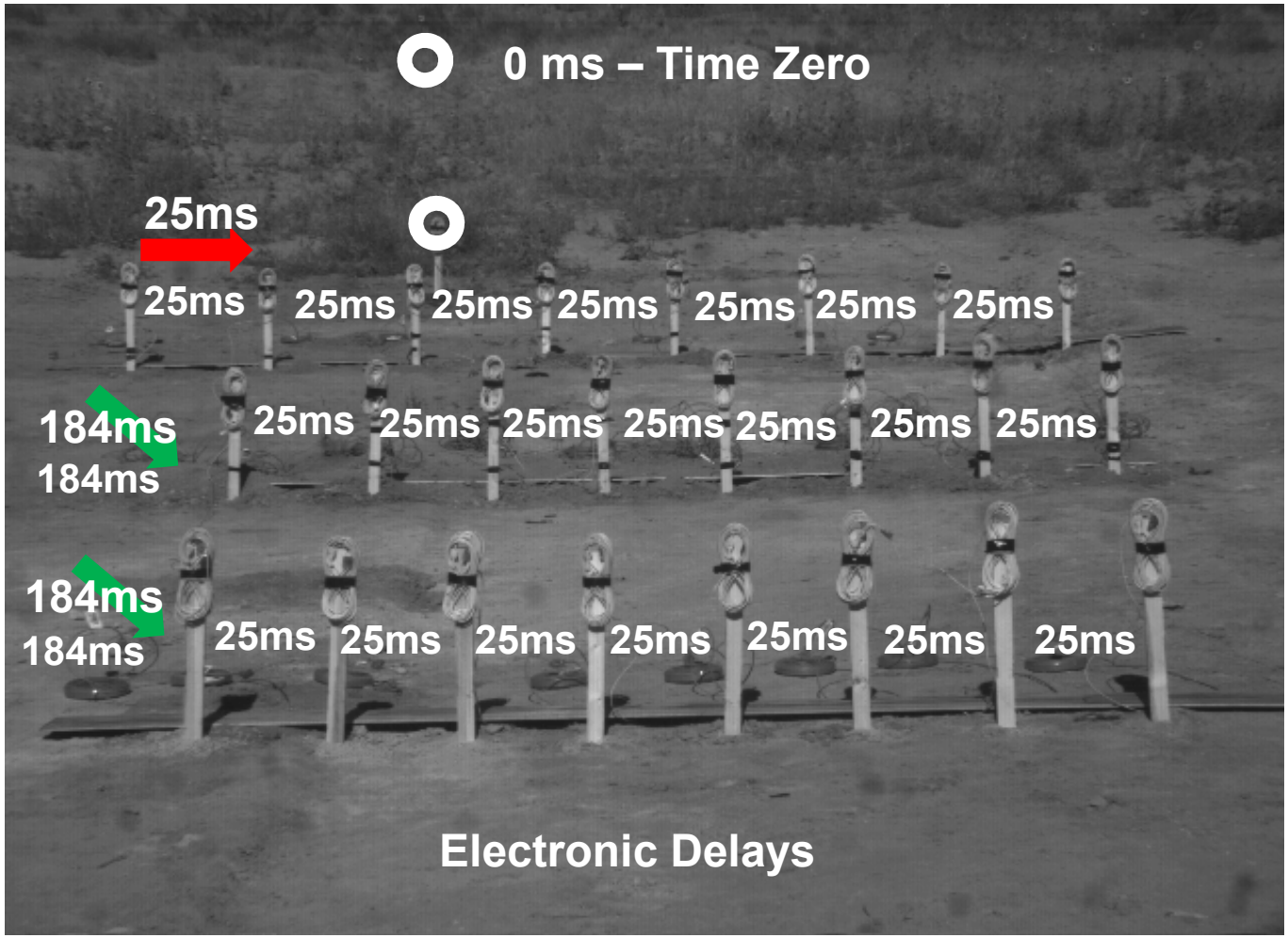
Putting in all together - Electronic



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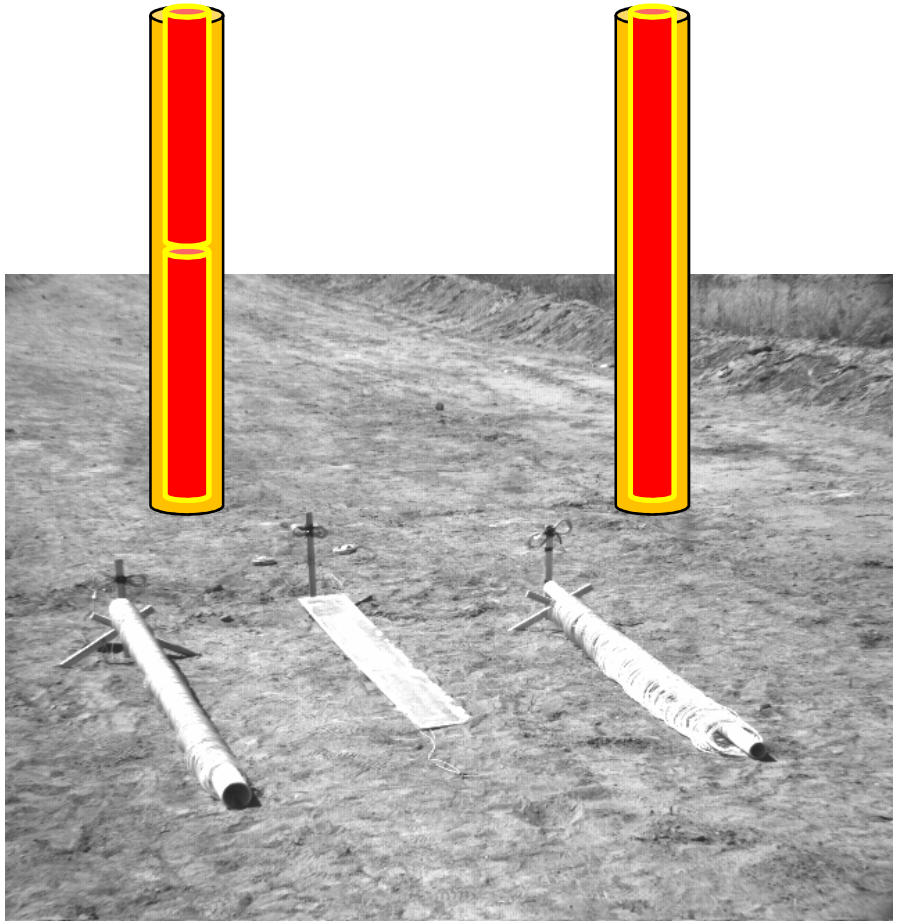
Explosive Detonation… Increased Value

- Another Old Rule of Thumb - Borehole priming with two primers on different delays… bottom-hole priming!
- What if… Decrease the time to detonate a column by HALF!
- What can this mean…? Better fragmentation…
- Even less potential for borehole explosive velocity causing overlapping of energy release (remember 1-2 ms can make a difference.)



- tst5.avi

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Explosive Detonation… Increased Value

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Underground Value

- Whether its Horizontal Development or Production blasting… electronics provide an even more significant value and production opportunity
- UG blasting generally relies on LP - **L**ong **P**eriod delays
- Production blasting has always been limited in size of shots and risk of out of sequencing of holes in a blast due to the extreme delays required
- Development blasting and in particular perimeter holes / timing control can be greatly affected by delay scatter

tst6.avi

tst7.avi

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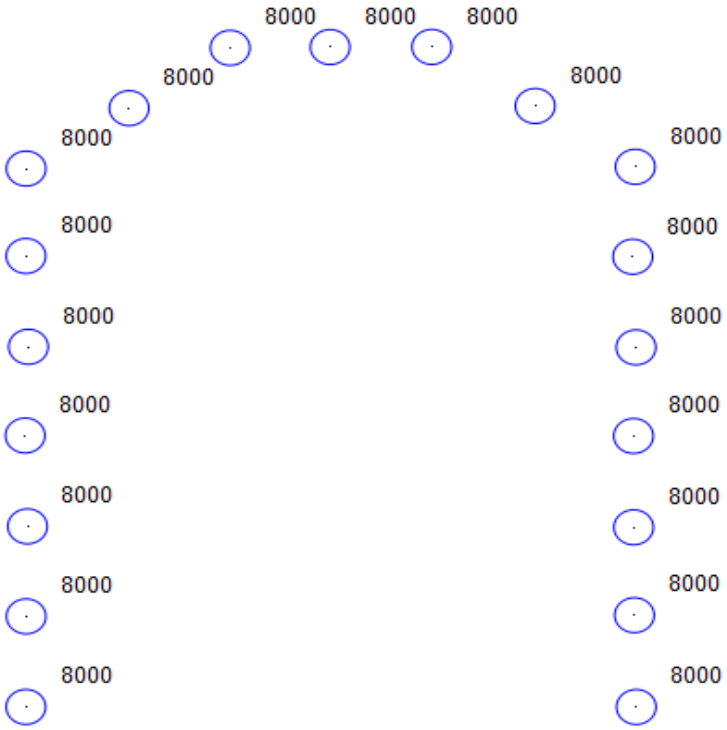
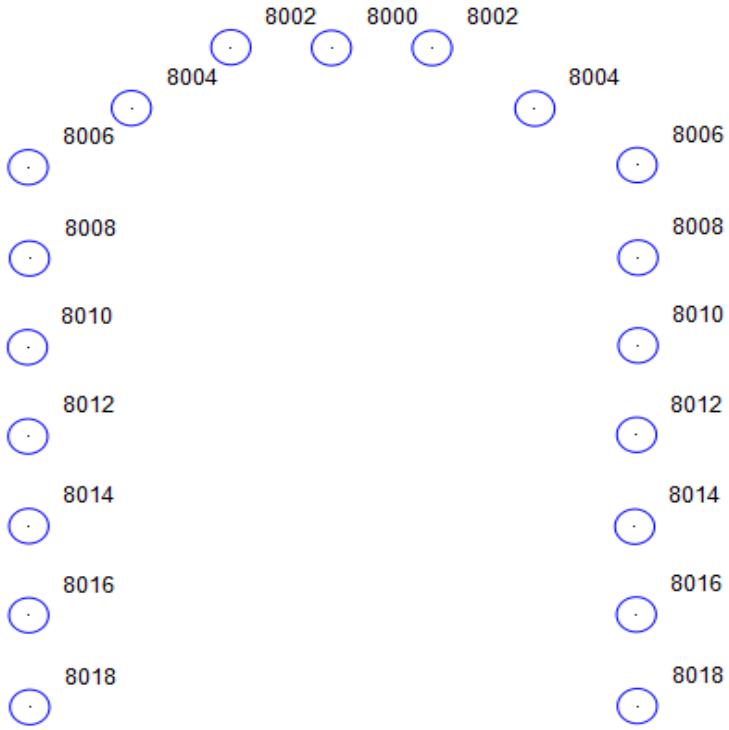
Under Ground Perimeter Value Design

Pyrotechnic



Electronic



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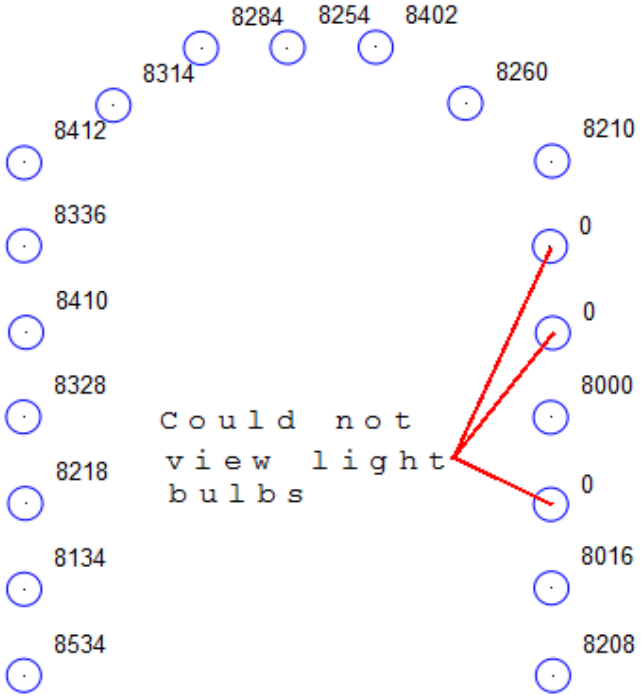
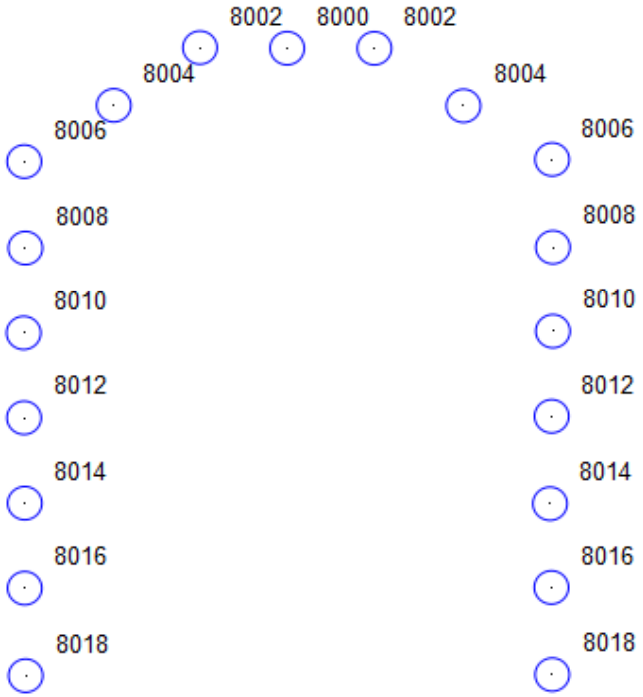
Under Ground Perimeter Value
Actual firing times
Pyrotechnic Electronic





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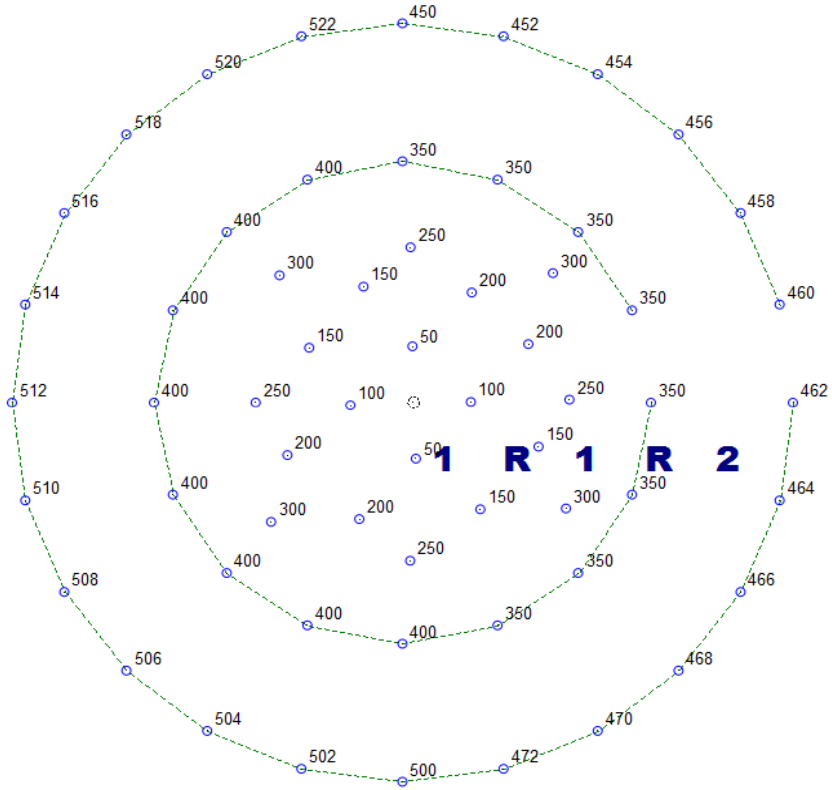
Underground Value



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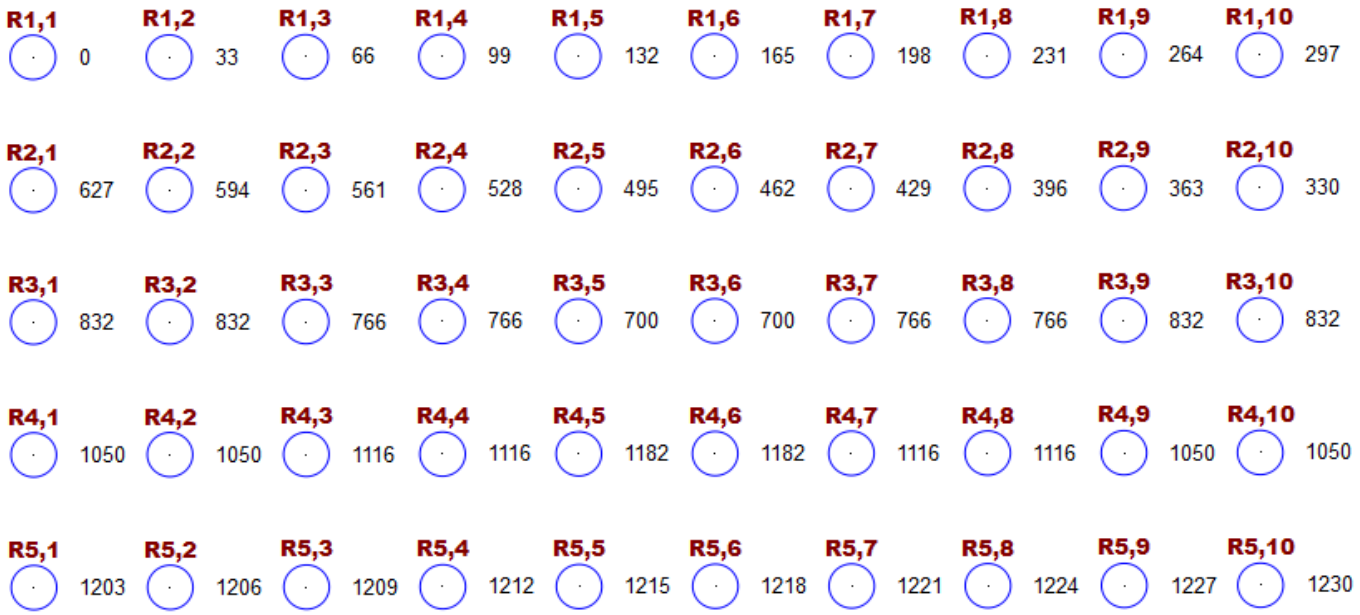
Flexibility of Timing Minimal Storage

Electronic Delay - Flexible Timing Scheme



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Flexibility of Timing Minimal Storage

- One cap needed, just variable lead lengths in inventory…
- Total flexibility of timing design in 1ms increments
- Not locked into a design even within a shot...
- Finally can execute on any design and the actual will match.
- Up to the blast time design changes…

- Tst8.avi

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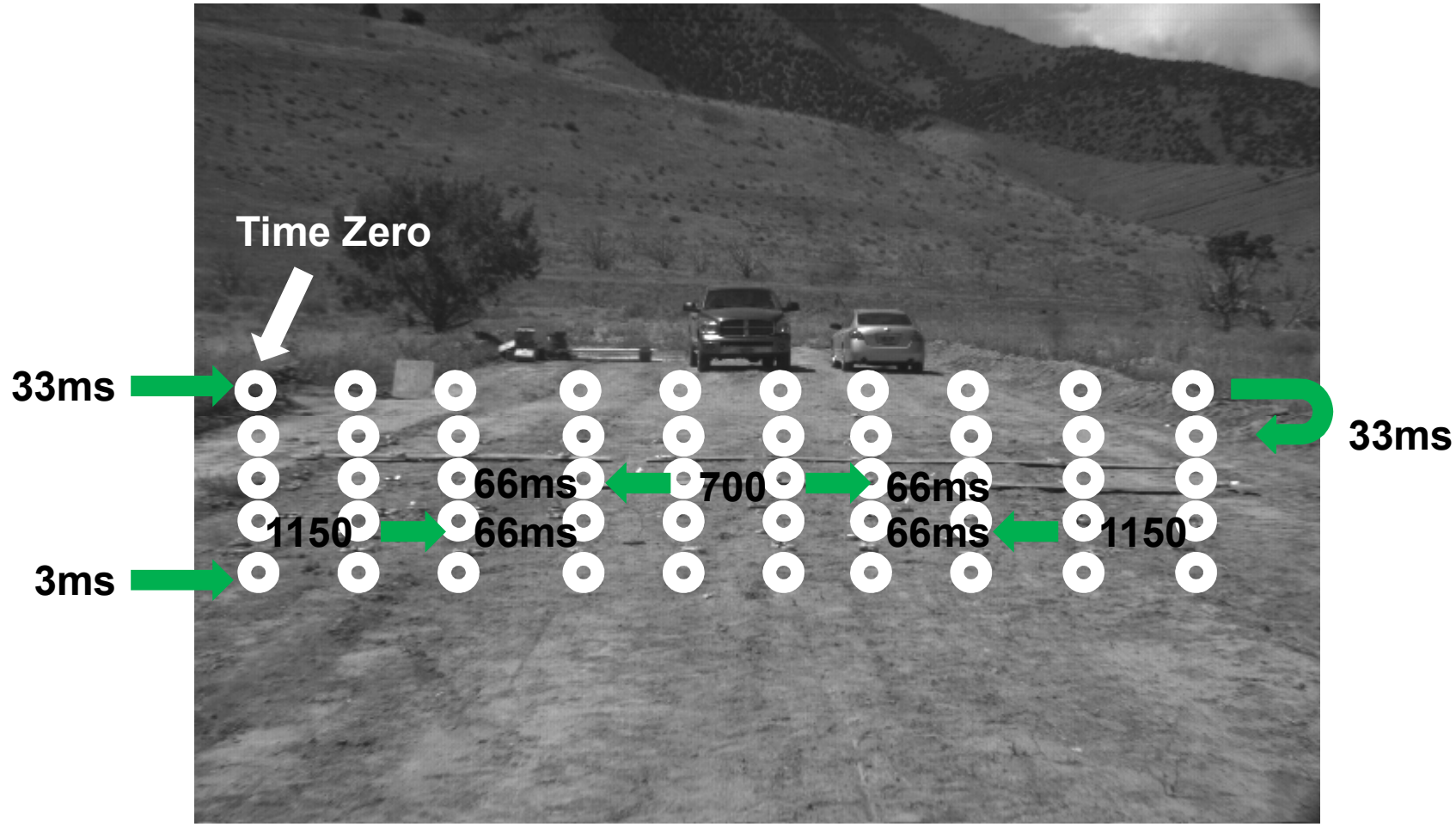
Flexibility of Timing



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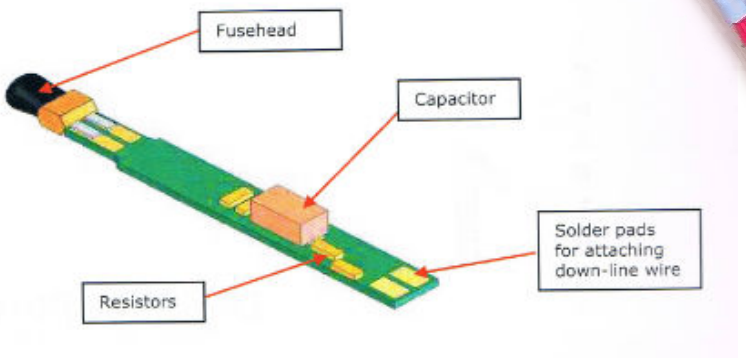
Communications and Testing…

- In addition to Precision AND Accuracy, one of the most significant features and benefits that electronic detonator technology provide is their ability to communicate.
- Communication provides the ability to test for functionality “in the hole”.
- Safety and Security is increased through in ability for unauthorized use.
- Communication takes place with Inherently safe equipment.



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THANK YOU

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