Universal Dual Safe Training Fuze For Mortars

Presented by: Michael De Gregorio

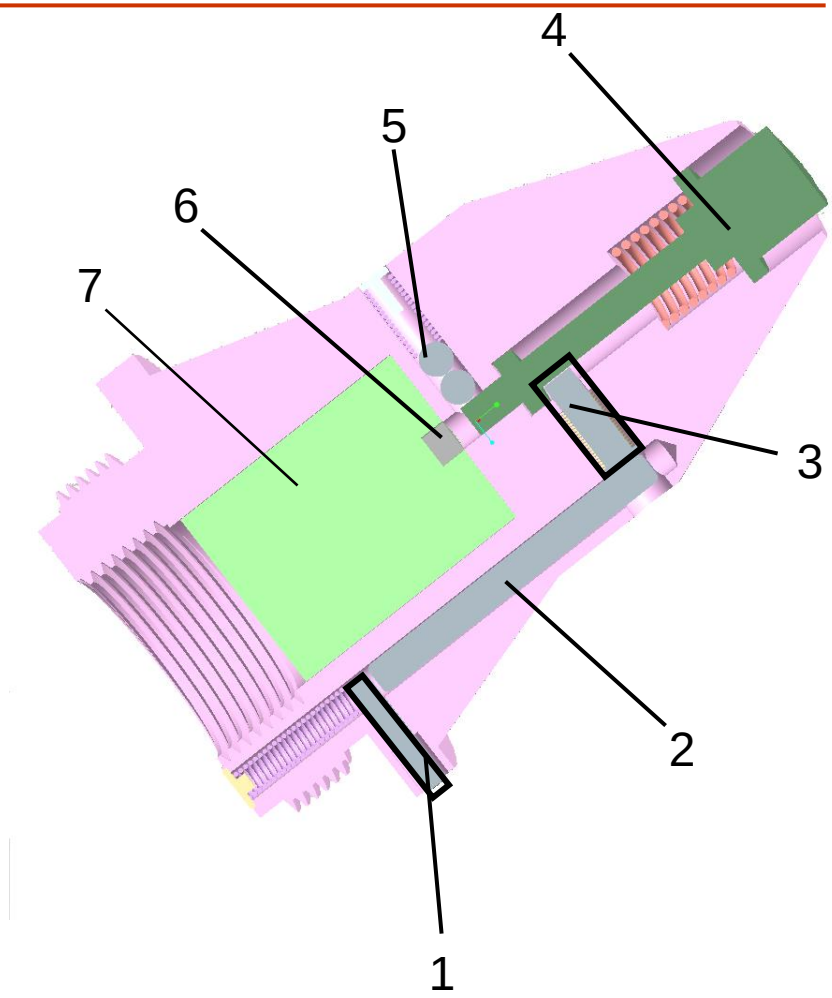
Prepared by: Michael De Gregorio and Eugene Mogendovich

Current Situation

- Mortar Training Fuzes are only single safe and released for use with a waiver from the AFSRB.
  - Arm on setback.
  - Require a pull pin for safety during transportation.
- Each training cartridge has its own variant of the training fuze.
  - 60mm M769 → M775 Fuze
  - 81mm M879 → M751 Fuze
  - 120mm M931 → M781 Fuze
- There is a reliability issue at charge 0 on the M751.
  - During PQT of the M879 cartridge (M751 Fuze), a ballistic reliability of 27.2% for charge 0 was demonstrated.

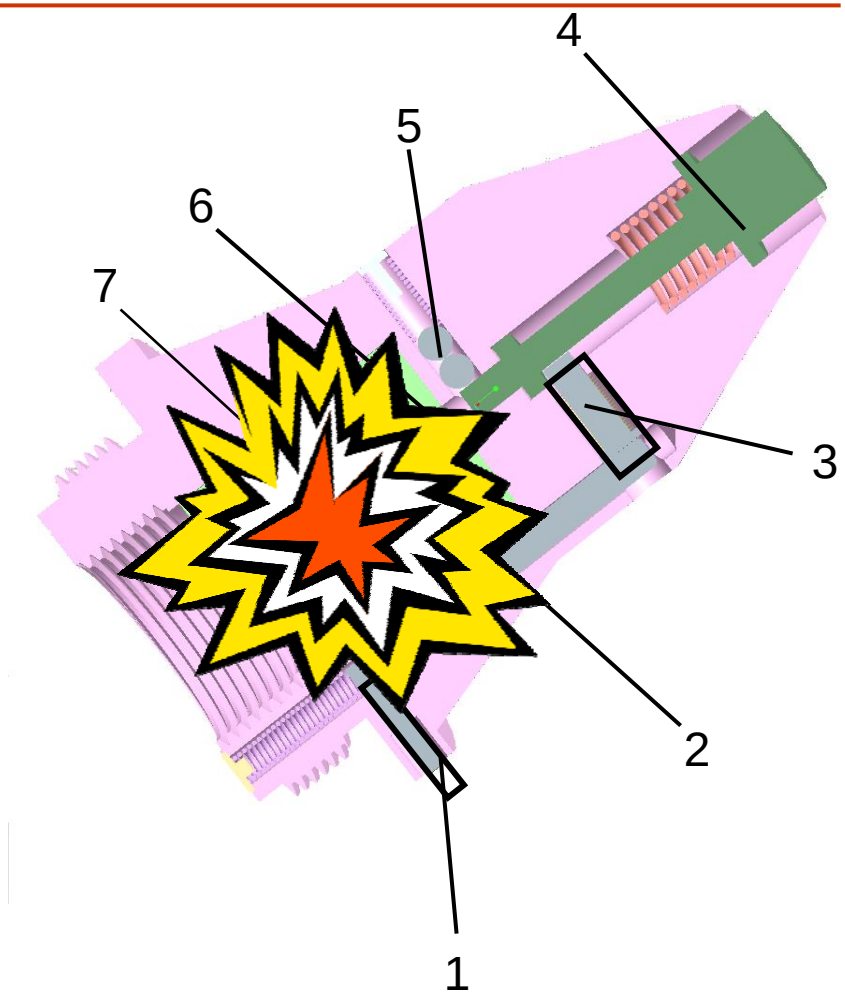
Current Design

- During shipping and handling, the fuze is kept safe by a combination packing clip and pull pin (1). Prior to firing, the pull pin is removed by hand.
- Upon firing, the acceleration moves the setback pin (2) rearward against the spring, releasing a slider (3), which has been holding the striker (4) in its rearward position.



Current Design

- Once the striker (4) is released, it travels upward allowing the ball bearings (5) to be forced into central alignment between the striker (4) and the primer (6).
  - Model does not show the plastic covering that keeps the striker (4) from flying out of the fuze once it is released.
- Upon impact, the striker (4) is driven into the ball bearings (5) which detonates the primer (6), igniting the spotting charge (7).



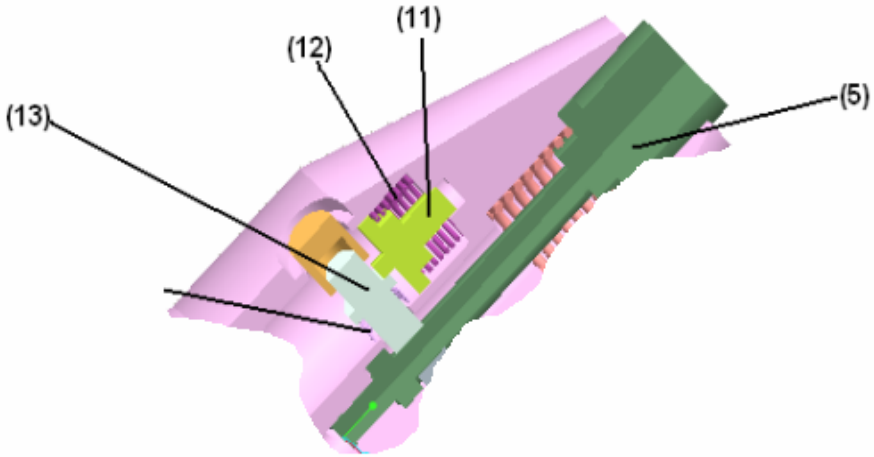
Proposed Solution

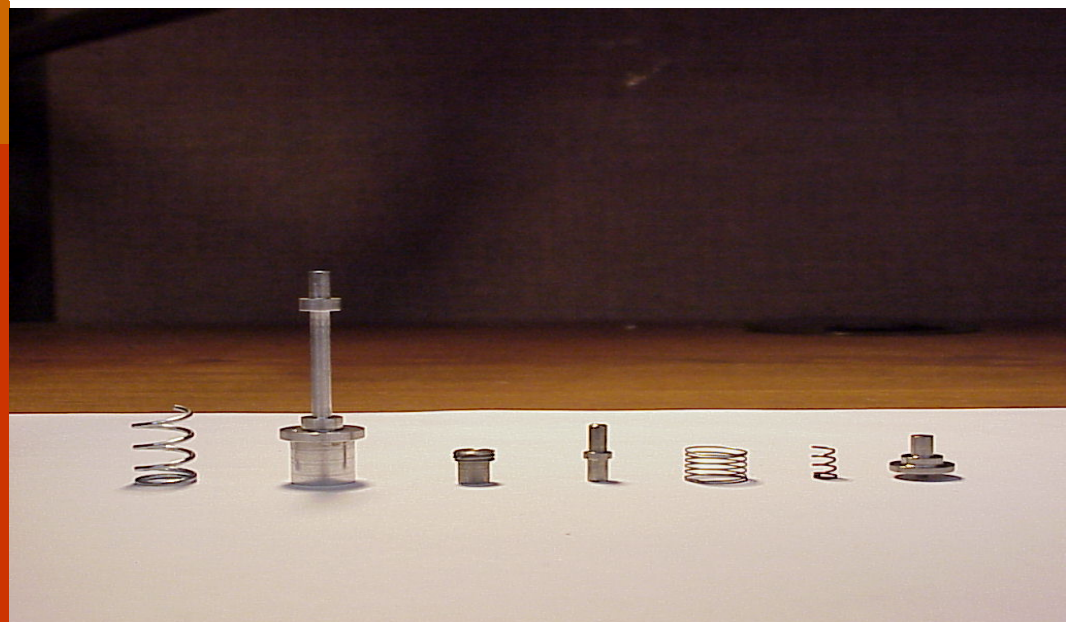
- Develop a Mortar Training Fuze that will work across all cartridges.
  - Add a second safety that meets MIL-STD-1316 and remains low cost.
    - Look at the use of set-forward after tube exit.
    - Will get rid of the pull pin.
  - Optimize the current setback mechanism for all charges on all systems.
  - Work with Pyrotechnics and Ballistics Groups to come up with one spot charge for all cartridges.

The Game Plan

- Complete the work on the second safety.
  - Design work.
  - Testing.
  - Characterize the set-forward environment for mortars.
- Standardize the existing first safety.
  - Commonize set-back pins.
    - Increase the reliability of the M751 at charge 0.
- Standardize the spotting charge.

The Road to a Second Safety





- Design Concept
  - Drag force and gravity deceleration during the ballistic flight move the set-forward pin (11) forward against the spring (12), releasing the slider (13), which had been holding the striker (5) in its rearward position (the second safety) .

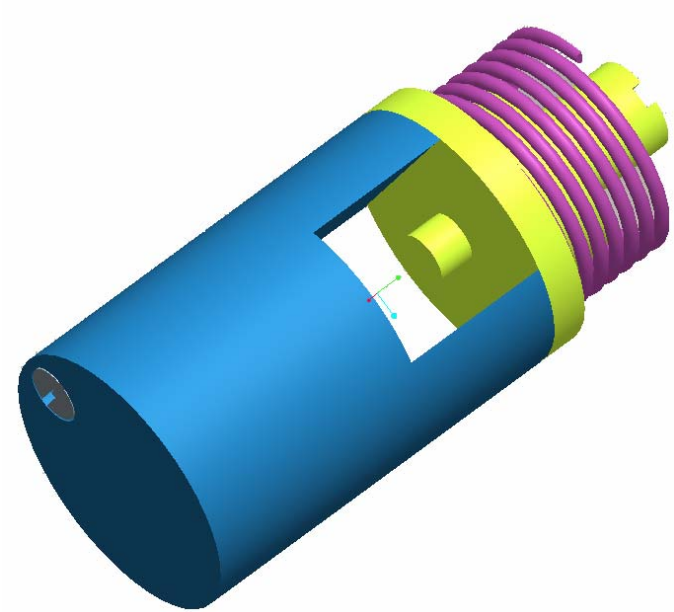
The Road to a Second Safety

- A test was held on 6 March 2006 to prove out our concept.
  - Used the centrifuge to simulate the set forward event.
  - Found that we needed approximately 200 Gs of force to release the set-forward lock.
- At this point, we were uncertain as to what set-forward forces we would have to work with.
  - Environment not characterized for mortars.
- However, we were certain that we would be working with less than 200 Gs of set-forward.
  - Redesign needed.

	Rotation (rev/min)	Gs	Comment
Striker Without Spring	446	111	Released
Striker With Spring	638	226	Released

The Road to a Second Safety

- Work began on an improved design.
  - A heavier design of the set-forward pin would lower the Gs needed for activation of the safety.
- This design was tested on 24 October 2006.
  - Reduced activation Gs from 200 to 20.
  - Experimented with Lubricants.
- Still felt that the Gs needed to be reduced further.



Original Design (Gs)	Dry Parts (Gs)	CRC Power Lube (Gs)	143DF PTFE (Gs)
226	23.2	33.4	27

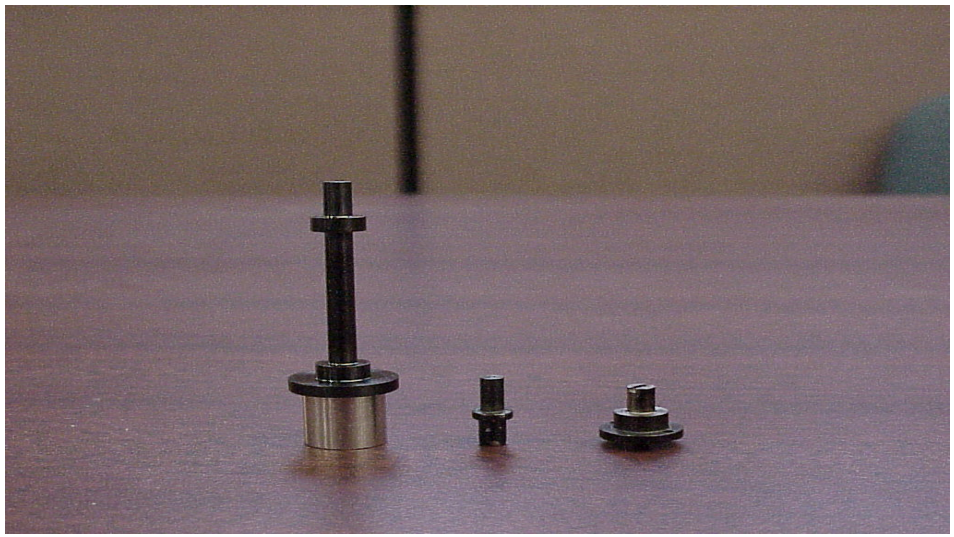
Mean Values for each case.

The Road to a Second Safety

- Set-forward environment hard to characterize empirically.
- Ballistic test required to characterize the forces seen on the projectile throughout its entire flight.
  - Looking for a unique event that is independent from set-back.
  - Awaiting the fabrication of telemetry units.
  - Once this test is complete we will know for certain the forces that we have to work with.

The Road to a Second Safety

Fuze #	Radius (in)	Rotation (rpm)	Gs	Comment
1	19	200	21.6	Released
2	19	325	57	Rough belt finishing
3	19	210	24.0	Released
4	19	180	17.5	Released

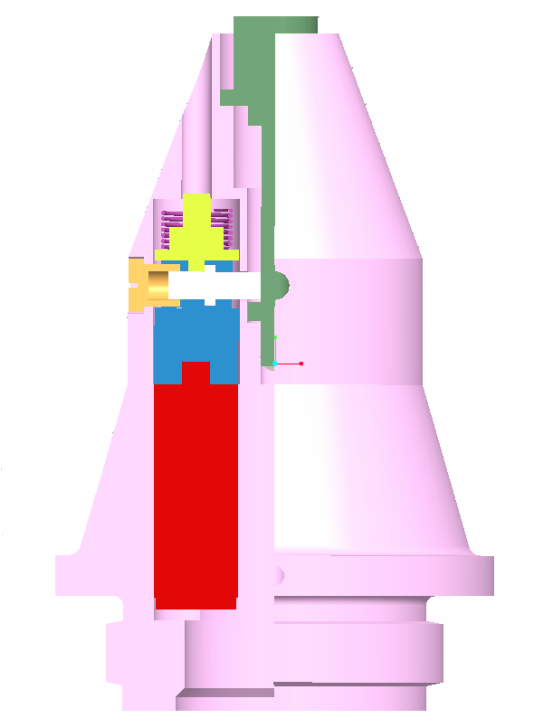


- Tested same design with all parts coated with low friction Molybdenum Disulfide Titanium (MoS_2Ti).
- Results showed that the parts reacted more consistently when coated with MoS_2Ti.
  - Mean value was 21 Gs.

The Road to a Second Safety

Original Design (Gs)	First Iteration (Gs)				Second Iteration (Gs)
No Lubricant	No Lubricant	Power Lube	143DF PTFE	MoS_2Ti Coating	MoS_2Ti Coating
226	23.2	33.4	27	21	13.4

Mean Values



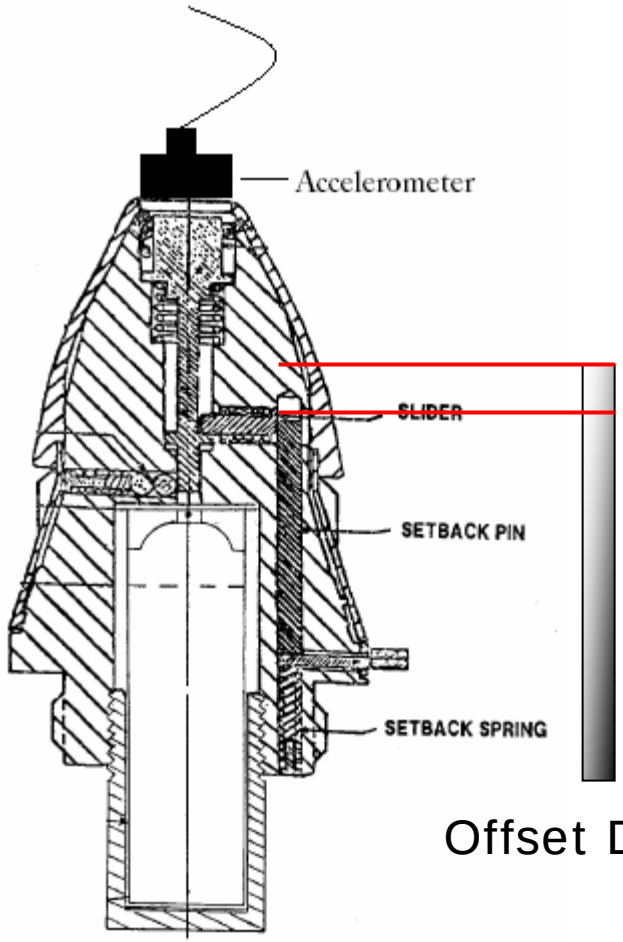
- We have completed another design iteration.
  - Adjustable weight design for testing purposes.
    - Three times as heavy as the last design when using the largest extension. Twice as heavy when the smaller extension is used.
  - Tested this design on 9 May 2007.
    - Mean Value was 13.4 Gs.
- The results of this test, when compared to the ballistic forces that are being collected by the telemetry units, will tell us whether or not set-forward is a viable option.

A Complete First Safety

- In parallel to the second safety effort, an effort is being made to fix the charge 0 reliability issues associated with the M751.
  - Using this as a springboard for standardizing the set-back mechanisms across all cartridges at all charges.
- Three solutions were looked at:
  - Change hollow pin to a solid pin.
  - Increase the depth of the setback chamber and the length of the pin (offset design).
  - Implement a zigzag design in the current hardware.

A Complete First Safety

- Performed a drop test 12 December 2006.
  - One accelerometer was placed on top of the fuze in the striker hole to observe the forces within the fuze during the drop and upon impact.
- We then developed a model and used this data to verify our results.
  - Allows us to trust the results of our model.



Offset Design

Original Design

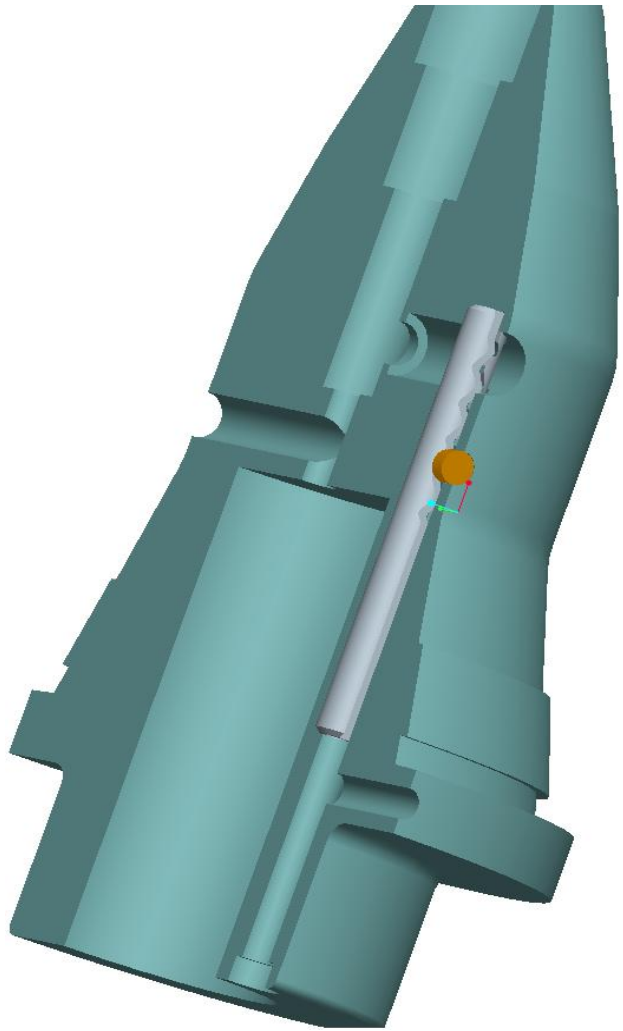
A Complete First Safety

Case	Drop Results	Firing Results (Charge 0)
Hollow Pin, no offset (Current Configuration)	Pass	Does Not Arm (27.2% historically)
Hollow pin, .04 offset	Pass	Does Not Arm
Average Weight Pin, .04 offset	Pass	Does Not Arm
Solid Pin, .04 offset	Does Not Pass	Arms

A Complete First Safety

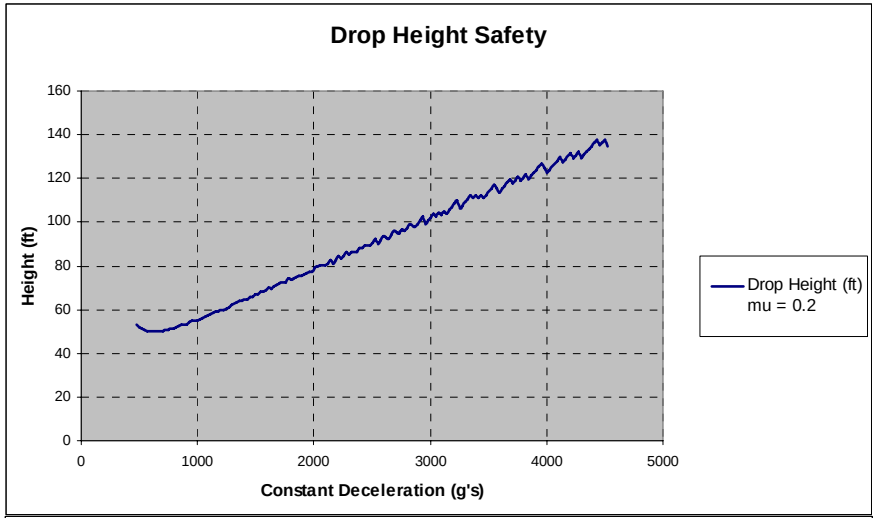
- Zigzag Pin Design
  - Currently working with Craig Routh and Stew Genberg from Adelphi to come up with a design.
- General Concept:
  - Create a zigzag channel down the length of the set back pin.
  - Drill a hole on the side wall of the fuze to expose the set-back pin's track.
  - Press fit a pin into the hole. This will cause the set back pin to follow the zigzag track.

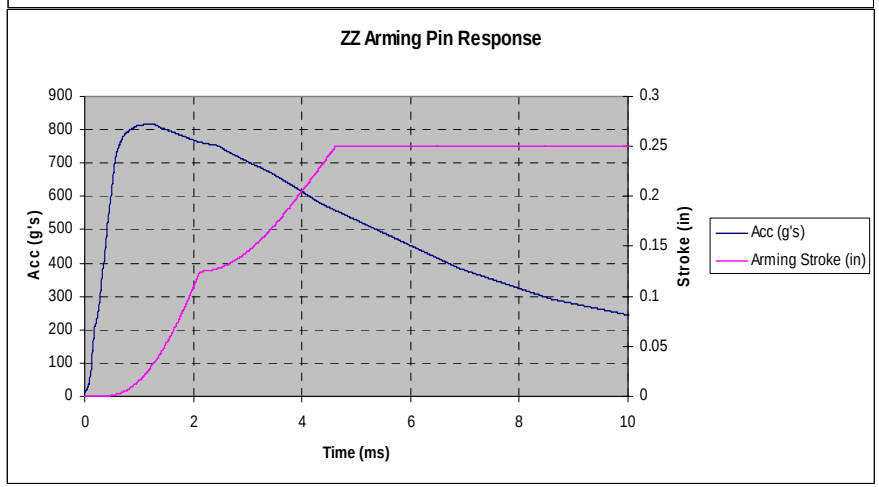
Note: Initial measurements determined that the M734 setback pin will not fit within the material allowance.



A Complete First Safety

- Prototype hardware has been cut.
  - To be tested on centrifuge at Adelphi
- Modeling indicates a drop safety height of 50 feet and an arming time of approximately 4.5 milliseconds.





Conclusions

- Use of set-forward as a viable environment in Mortar Fuzing is TBD.
  - Dependent upon the results of the telemetry test.
  - Alternative designs are be looked at just in case.
    - Air Pressure Lock
    - Venting Chamber Design
- Preliminary zigzag design is being fabricated at Adelphi.
  - Testing to be done to verify the design.

Questions?

- Michael De Gregorio
  - (973)724-9460
  - Mike.degregorio@pica.army.mil
- Eugene Mogendovich
  - (973)724-2019
  - Emogend@pica.army.mil
  - Eugene.mogendovich@us.army.mil