



# **NDIA**

## **45<sup>th</sup> Annual Fuze Conference**

### ***Design and Development of a new Electronic Time (ET) Fuze for Mortars (XM784/XM785)***

**18 April 2001**

**TACOM-ARDEC Fuze Division  
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**T**ank-automotive & **A**rmaments **COM**mand

## Report Documentation Page

<b>Report Date</b> 18Apr2001	<b>Report Type</b> N/A	<b>Dates Covered (from... to)</b> -
<b>Title and Subtitle</b> Design and Development of a new Electronic Time (ET) Fuze for Mortars (XM784/XM785)	<b>Contract Number</b>	
	<b>Grant Number</b>	
	<b>Program Element Number</b>	
<b>Author(s)</b> Pergolizzi, Anthony; Ward, Dennis	<b>Project Number</b>	
	<b>Task Number</b>	
	<b>Work Unit Number</b>	
<b>Performing Organization Name(s) and Address(es)</b> TACOM-ARDEC Fuze Division	<b>Performing Organization Report Number</b>	
<b>Sponsoring/Monitoring Agency Name(s) and Address(es)</b> NDIA (National Defense Industrial Association) 211 Wilson Blvd., Ste. 400 Arlington, VA 22201-3061	<b>Sponsor/Monitor's Acronym(s)</b>	
	<b>Sponsor/Monitor's Report Number(s)</b>	
<b>Distribution/Availability Statement</b> Approved for public release, distribution unlimited		
<b>Supplementary Notes</b> Proceedings from The 45th Annual Fuze Conference, 16-18 April 2001 Sponsored by NDIA, The original document contains color images.		
<b>Abstract</b>		
<b>Subject Terms</b>		
<b>Report Classification</b> unclassified	<b>Classification of this page</b> unclassified	
<b>Classification of Abstract</b> unclassified	<b>Limitation of Abstract</b> UU	
<b>Number of Pages</b> 25		

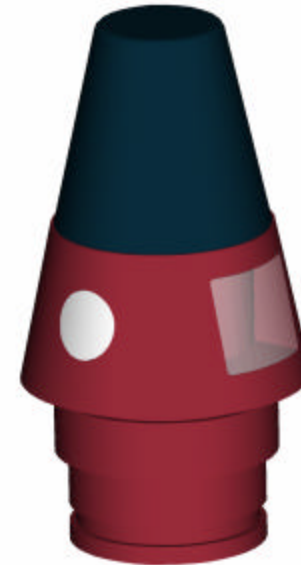


# XM784 / XM785 Electronic Time Fuze for Mortars

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- Background
- Need
- Requirements Overview
- Programmatic Approach
- Schedule
- Technical Approach





# **XM784 / XM785 ET Fuze for Mortars**

## ***Background***

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- **No US Fielded ET Fuze for Mortars Exists**
  - **US Requirements Filled By Foreign Source**
  - **M776 / M772 Diehl/Junghans (Germany)**
    - **Under Waiver From US Safety Standards**
- **User Persistently Indicated Need For a US ET Fuze (Since Mid '80's)**
- **No NDI Design Solution Exists**
  - **Foreign Comparative Studies**
  - **Engineering Studies**
  - **Contractor Studies**



# XM784 / XM785 ET Fuze for Mortars *Need*



- **Army Safety Standards**
  - **No Current Time Fuze Meets Standards**
- **Need For Increased Timing Accuracy**
  - **Poor Fuze Accuracy**
  - **Adversely Effects Cartridge Performance**
- **Three Fuze Types**
  - **PROX: (M734A1 Multi-Option Fuze)**
  - **PD / Delay: (XM783)**
  - **Time: (XM784 (60 / 120 mm) & XM785 (81 mm))**
- **Legacy Fuzes Require a Wrench To Set**
  - **Difficult to Read**
  - **Require External Lighting**
- **Mortar Time Fuze Modernization**



# **XM784 / XM785 ET Fuze for Mortars**

## *Requirements*

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- **Safety Per MIL-STD-1316 (Dual Environ Safety)**
- **Cartridge Compatibility:**
  - 60 mm (M721 Illum & M767 IR Illum)
  - 81 mm (M853A1 Illum, XM816 IR Illum & M819 RP Smoke)
  - 120 mm (XM930 Illum, XM983 IR Illum)
- **Hand Settable Required (Inductive Set Desired)**
  - Self Illuminating
- **Accuracy 98%**
- **Set Time 5 – 99.9 Seconds (0.1 Sec Increments)**
- **Cannot Significantly Degrade Cartridge Range**
- **20 Year Shelf Life (Controlled Environment)**



# **XM784 / XM785 ET Fuze for Mortars**

## ***Programmatic Approach***

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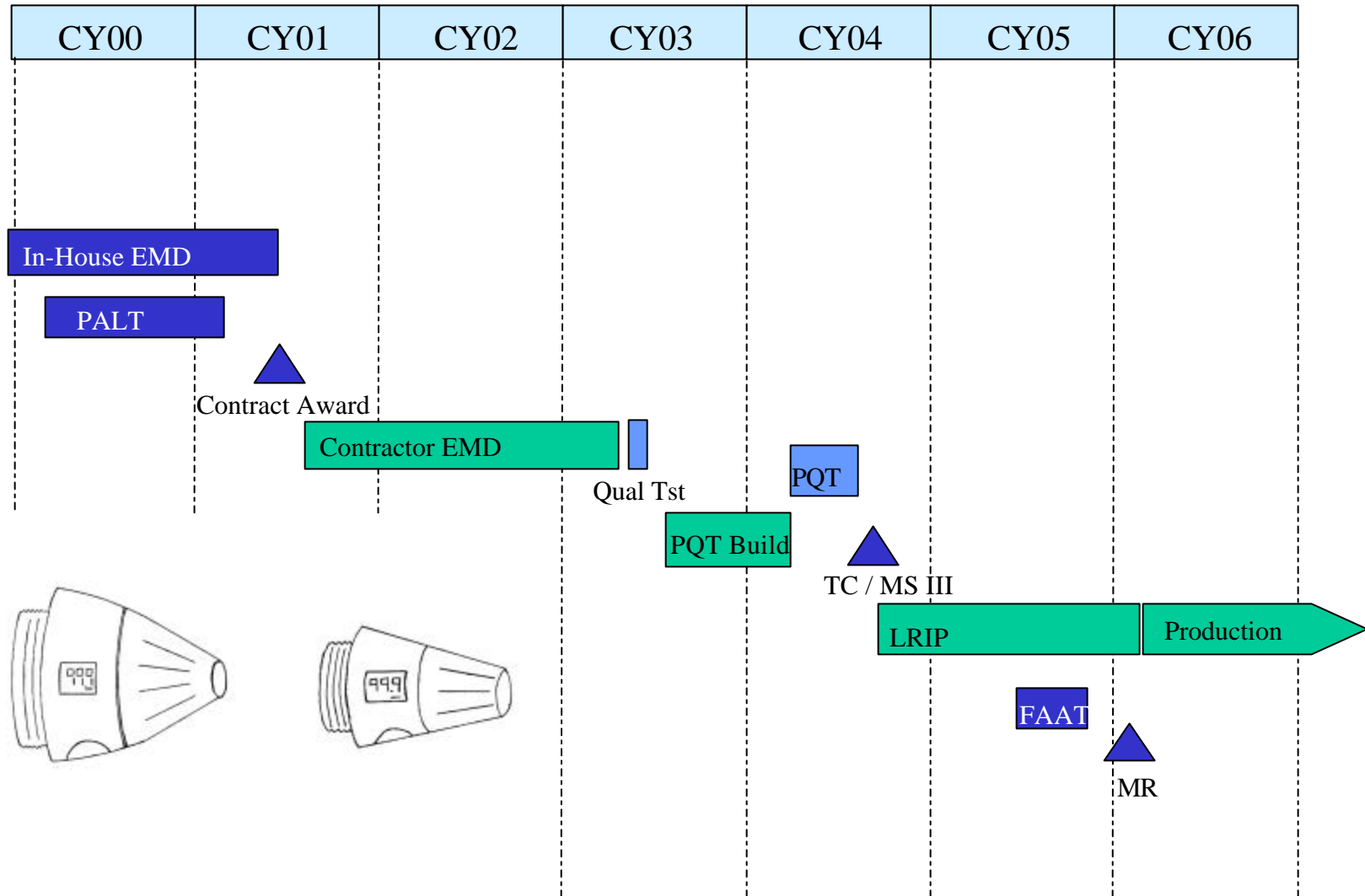


- **Systems Engineering / IPT Approach**
- **Initial Gov't Eng Activity – Risk Mitigation Effort**
- **Solicit Contractor – Competitive / Cost Plus Type**
  - **Phase 1: Develop & Demo Design Solutions (Award Fee)**
  - **Phase 2: Production Qualification / TC (Award Fee)**
    - **Conduct Government Ballistic Tests**
    - **TC Standard**
  - **Phase 3: Low Rate Initial Production (Incentive Fee)**
    - **LRIP Effort (22k – 60k fuzes)**
      - **FAAT**
      - **Three Production Lots to MR**



# XM784/ XM785 ET Fuze for Mortars

## Schedule





# **XM784/ XM785 ET Fuze for Mortars**

## *Technical Approach*



- **Maximize Use of NDI Components**
  - **Minor Modifications**
- **Initial In-House EMD**
  - **Develop Expertise For Source Selection**
  - **Development / Technology Exploration**
    - **Fuze Electronics**
    - **Power Source**
      - **Pre & Post Launch Battery Solutions**
      - **Non-Battery Solutions**
    - **Safety & Arming Device (incl 2nd Env Sensor)**
      - **Pressure Sensor**
      - **Muzzle Exit Sensor**
      - **Air Flow Sensor**
    - **Explosive Train**
    - **Packaging and Hand Setting**



# **XM784/ XM785 ET Fuze for Mortars**

## *Electronics*

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- **Developed a power budget**
- **Evaluated the tradeoffs of an ASIC vs a microcontroller**
- **Designed and fabricated generic surface mount breadboard**
- **Uses a lithium reserve battery (M762 style)**
- **Developed schematic diagrams, safety logic, flow charts, and block diagrams have been developed**
- **Uses an inertial “T<sub>0</sub>” switch and impact sensor**
- **Developed logic software for the main and safety microcontrollers**
- **Interfaced the logic software with the breadboard and conducted bench tests**



# XM784/ XM785 ET Fuze for Mortars

## *Power Supply*



- **Studied candidate solutions:**

### Electro-chemical

M80  
SD Fuze  
OICW  
M762  
Active lithium  
thermal

### Non-chemical

Piezo-electric  
Electro-magnetic  
Setback generator  
Fluidic generator  
Turbine alternator

- **Capacitor cost / performance trade-offs may prohibit non-chemical initiatives**
- **Evaluated both an Evans Capattery and M762 battery for operation with our circuit**



# **XM784/ XM785 ET Fuze for Mortars**

## *Second Environment Sensor*

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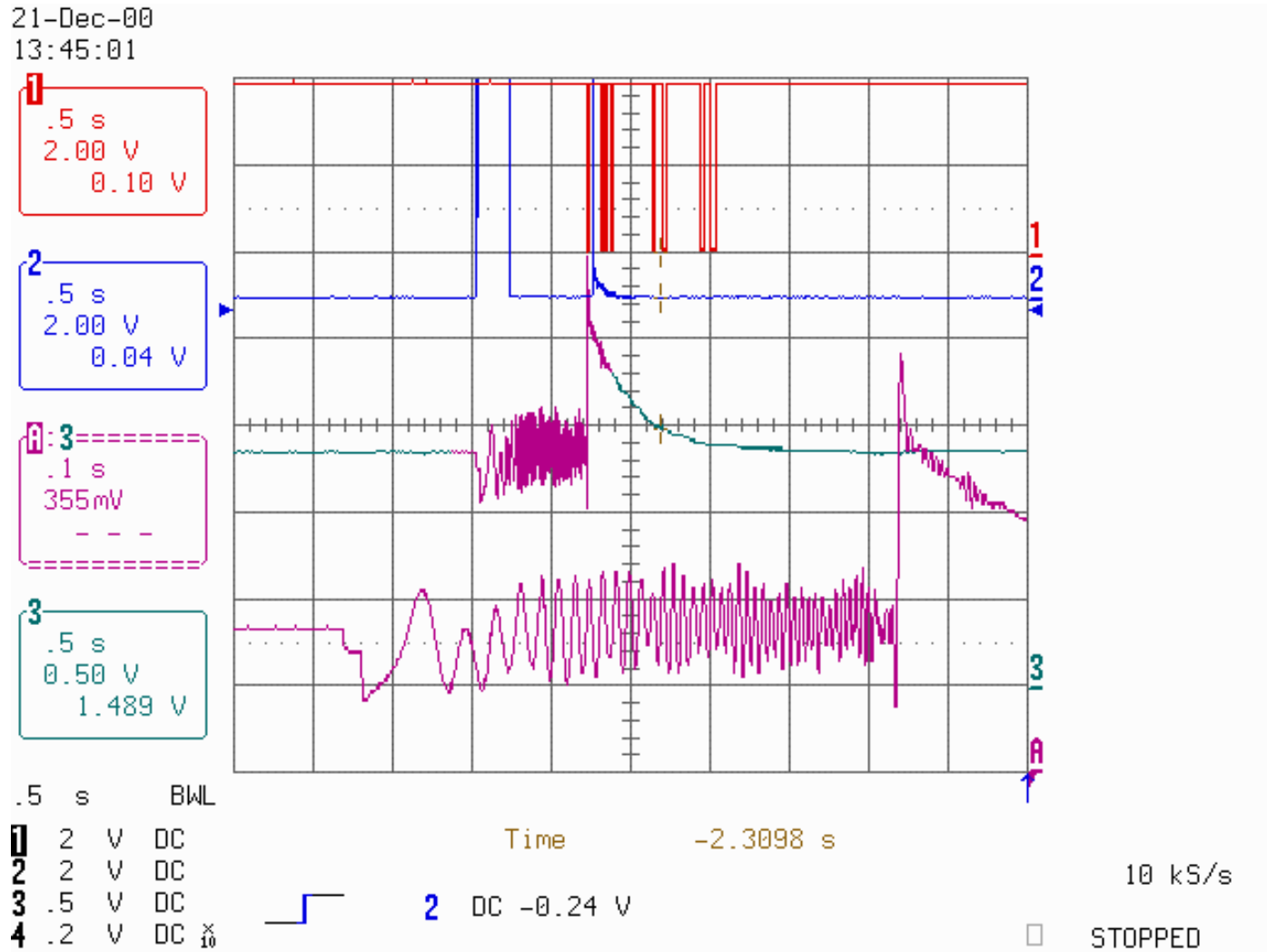


- **Researched several approaches:**
  - Pressure / Force
  - Muzzle Exit (Mag, ESS, RF)
  - Air Flow (Turbine driven lock)
- **Conducted RF sensor free fall drop tests**
  - 60mm, 81mm and 120mm tubes
- **Generated pressure profile plots**
- **Adapted a COTS pressure sensor**
  - Evaluated via laboratory flow-controller tests
- **Conducted aeroballistic tests in wind tunnel**



# XM784/ XM785 ET Fuze for Mortars

## *Second Environment Sensor*



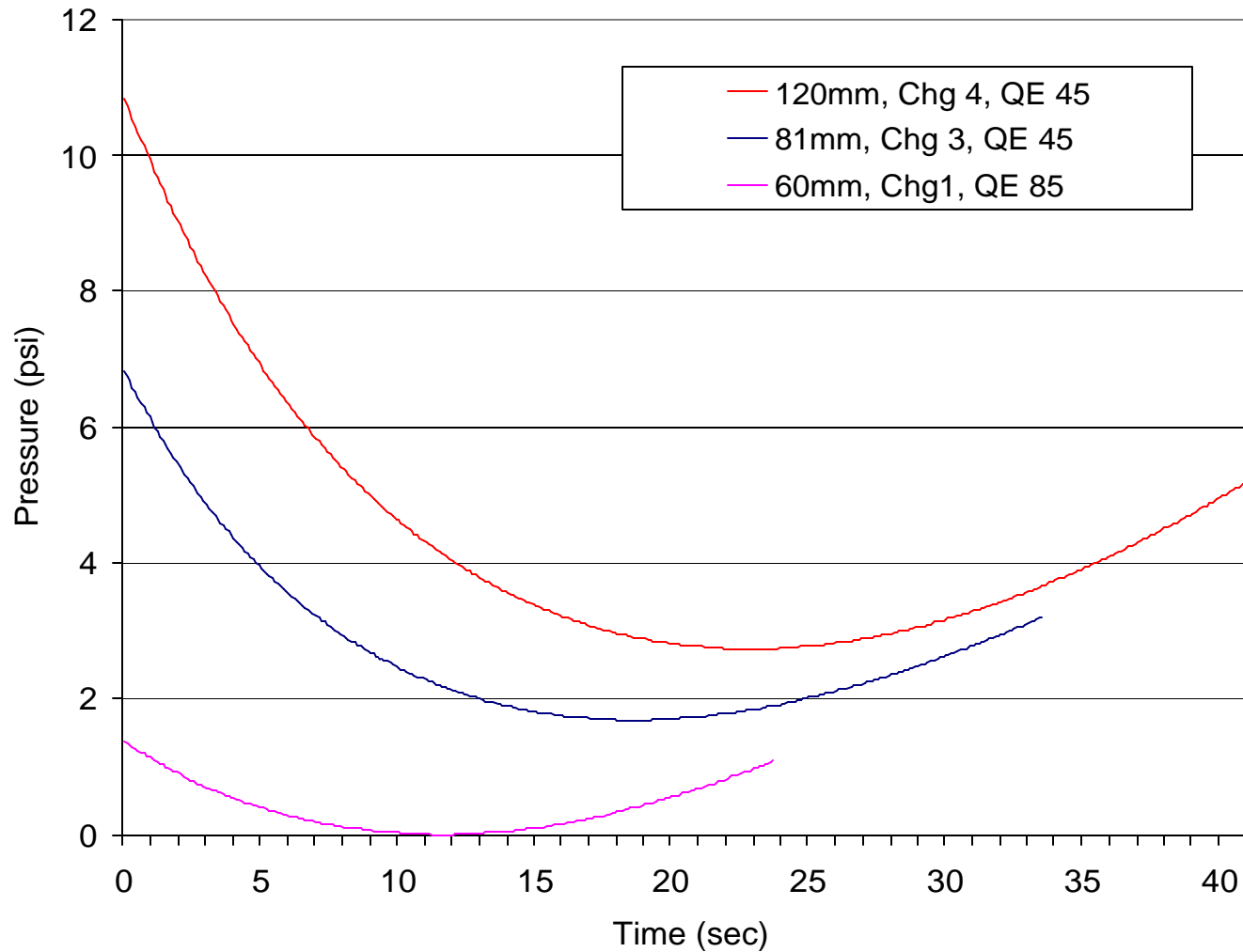


# XM784/ XM785 ET Fuze for Mortars

## *Second Env Sensor*



Calculated Pressure vs Time





# XM784/ XM785 ET Fuze for Mortars

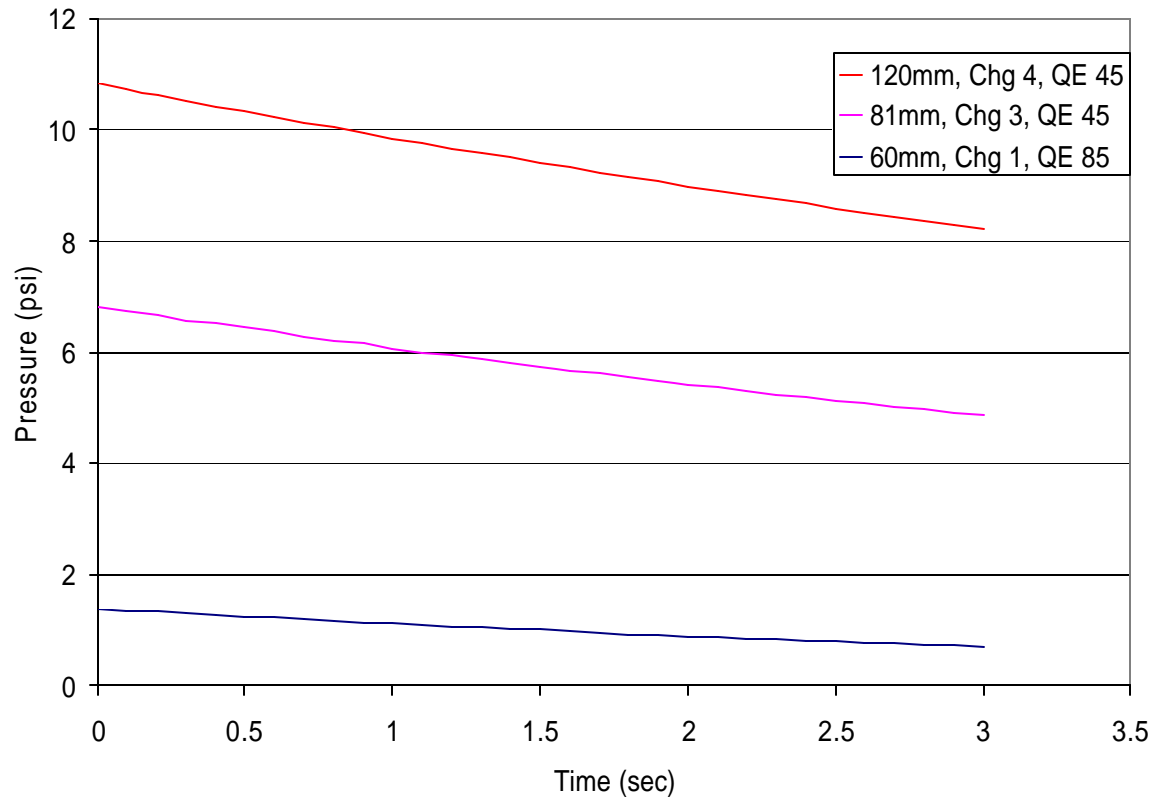
## *Second Env Sensor*



*(Calculated Pressure - First 3 secs of Flight)*

Calculated Pressure vs Time

Chg @ QE45	Press Range (psi)
60mm	1 1.4 - 0.9
	2 2.7 - 1.7
	3 4.2 - 2.7
	4 5.8 - 3.7
81mm	1 2.1 - 1.4
	2 4.2 - 3.0
	3 6.8 - 4.8
	4 9.7 - 6.8
120mm	1 2.5 - 1.8
	2 4.7 - 3.5
	3 7.4 - 5.6
	4 10.8 - 8.2



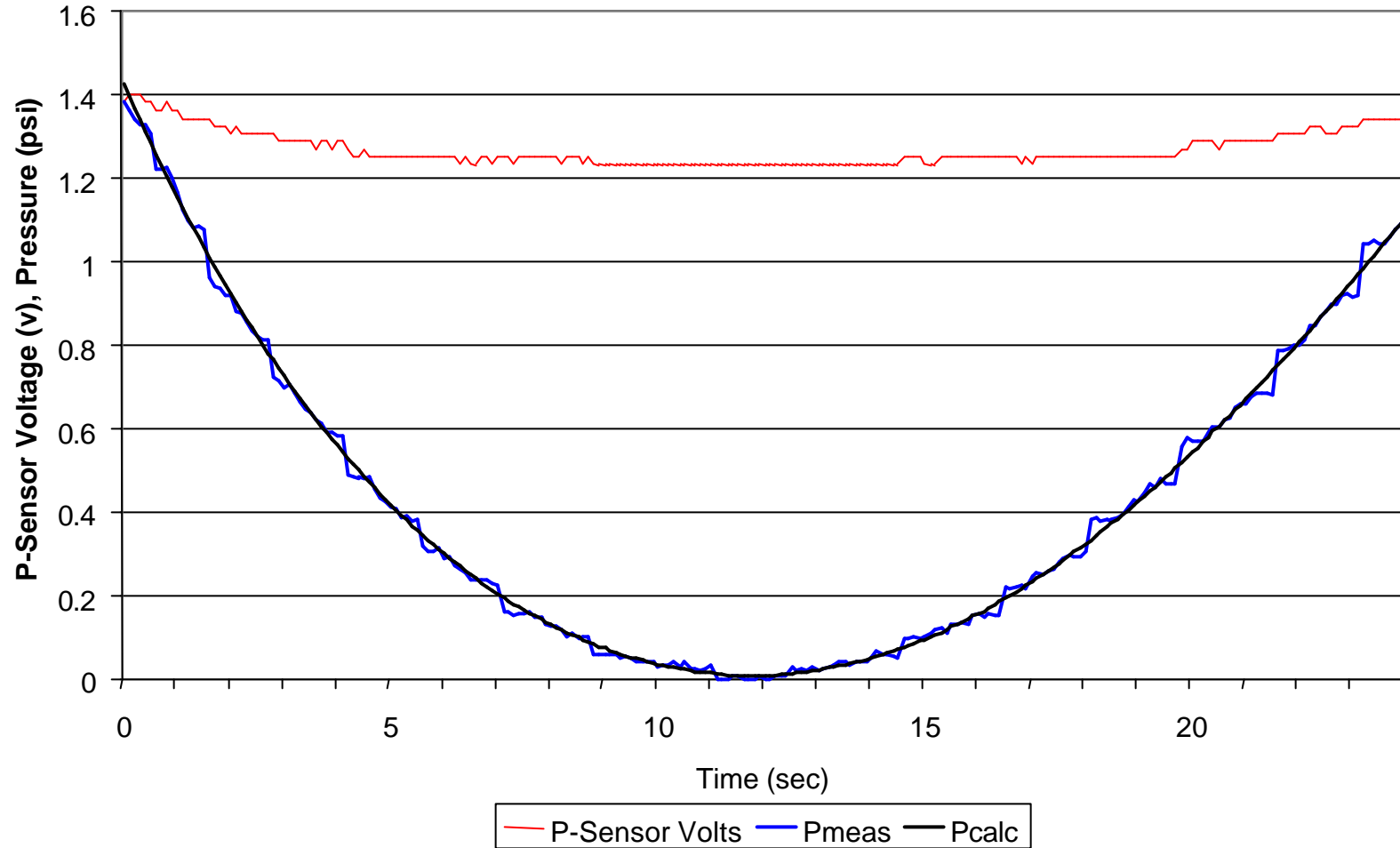


# XM784/ XM785 ET Fuze for Mortars

## *Second Env Sensor*



P-Sensor Output vs Time  
60mm, Chg 1, QE85





# XM784/ XM785 ET Fuze for Mortars

## *Safe and Arm Device*

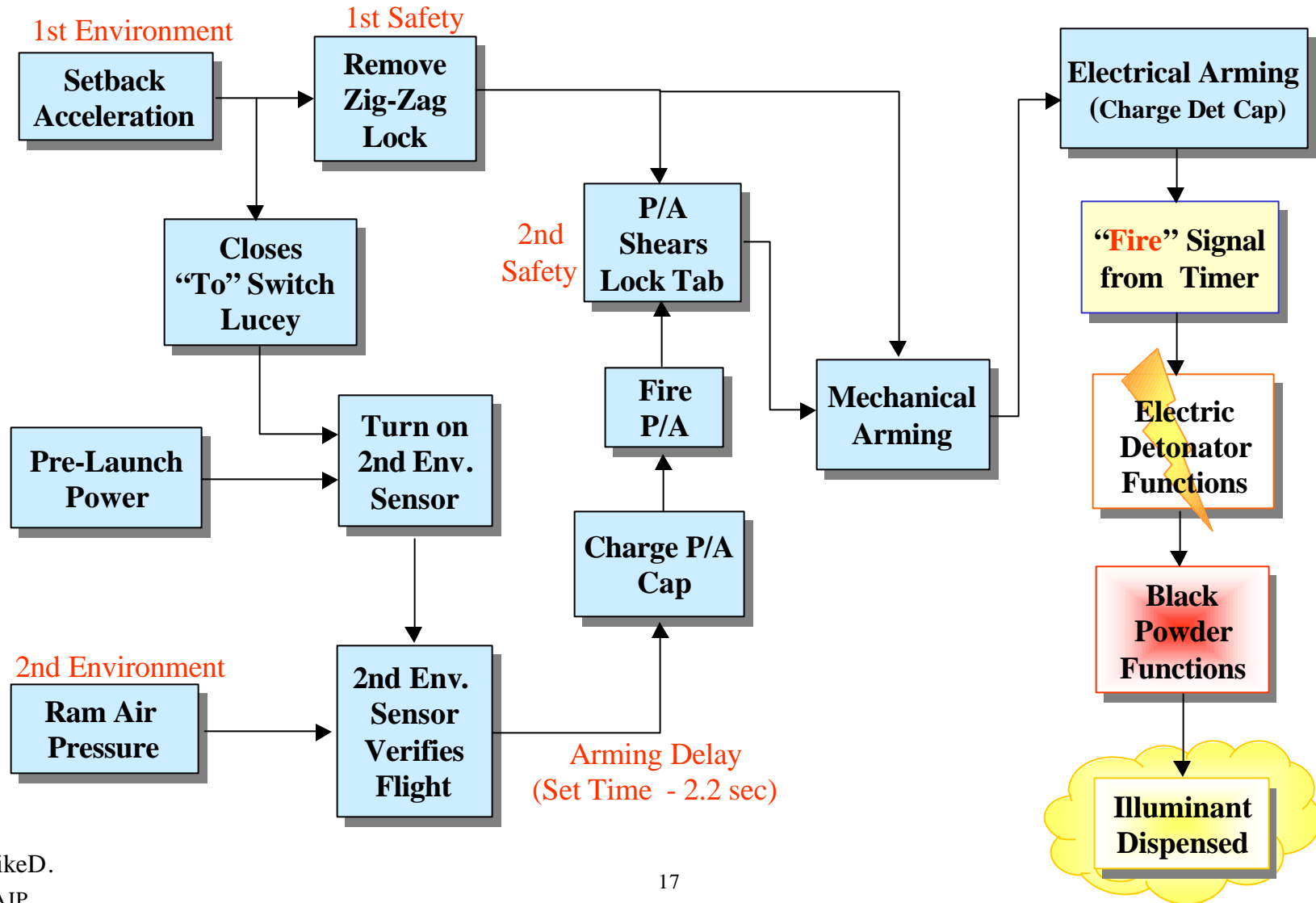


- **Design approaches:**
  - **Command arm w/ piston actuator (stored energy)**
  - **Evaluated air powered arming**
    - removing a lock then spring driven in-line
    - directly arming the fuze
- **Zig-zag setback lock with switch closure**
- **Designed both barrier and rotor approaches**
- **Develop PRO-E layout to generate SLA hardware**



# Safety Logic Diagram - ET Fuze for Mortars

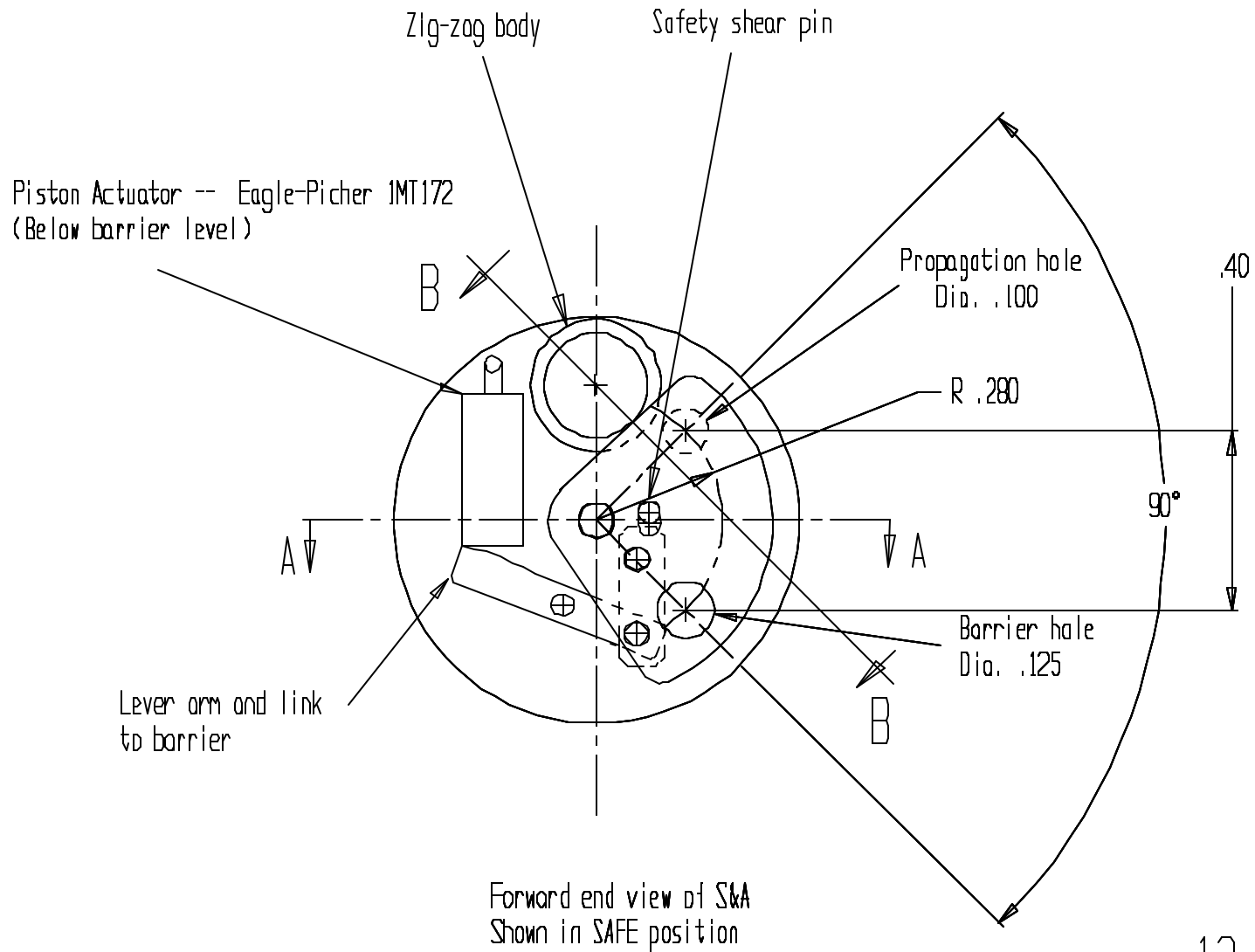
(Version B)





# XM784/ XM785 ET Fuze for Mortars

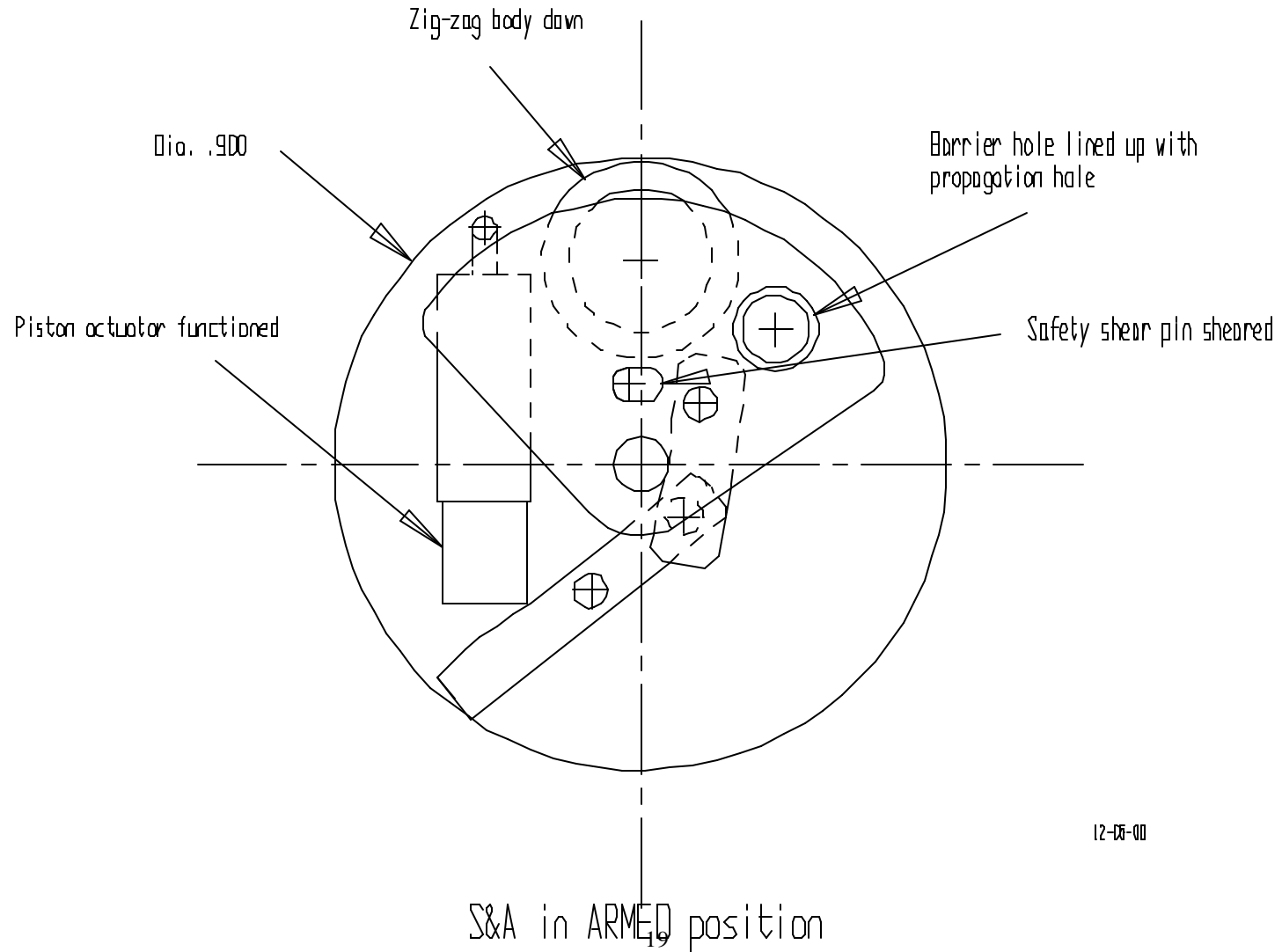
## S&A (safe position)





# XM784/ XM785 ET Fuze for Mortars

## S&A (armed position)



# XM784/ XM785 ET Fuze for Mortars

## S&A (zig-zag)

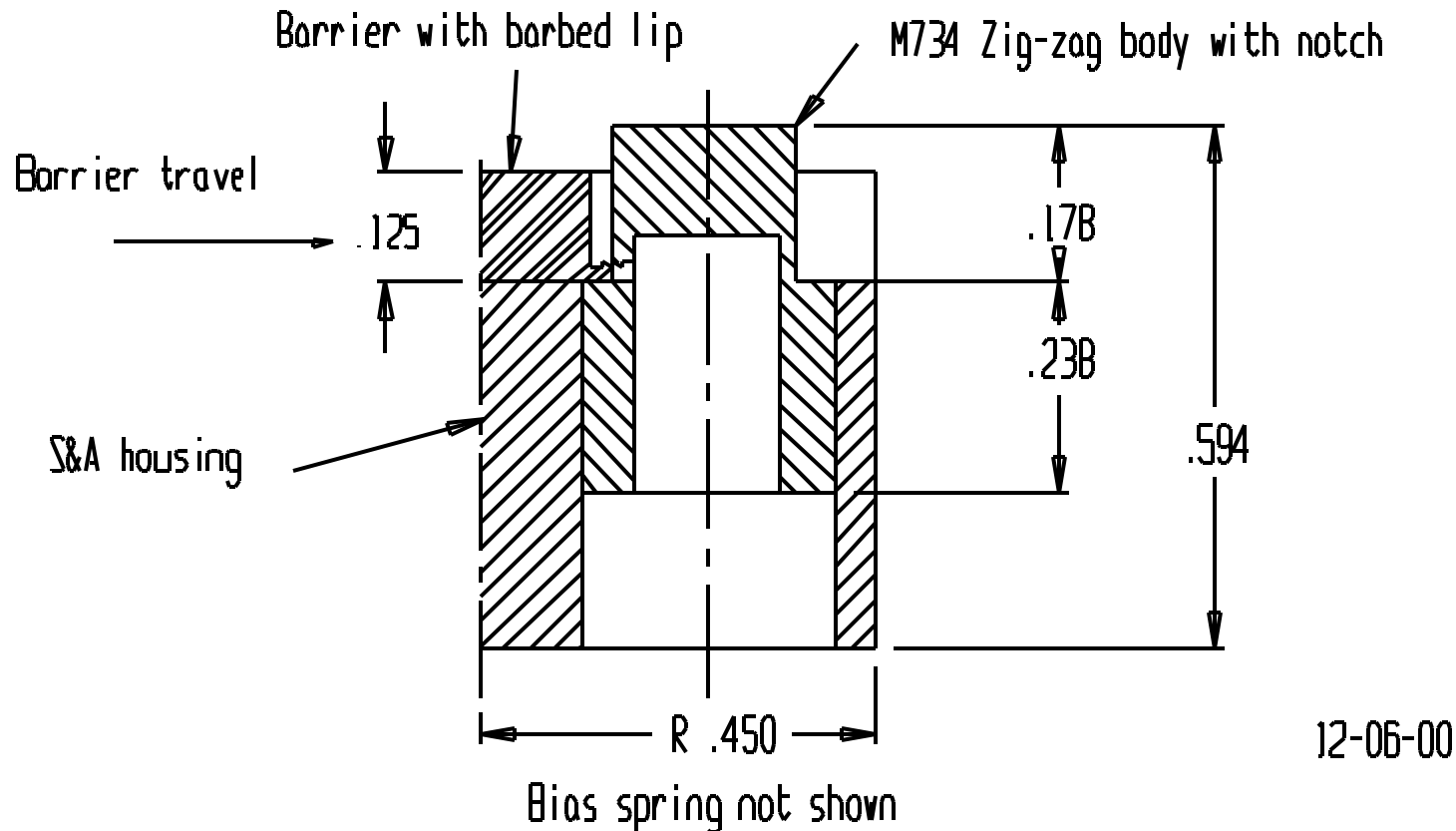


Fig. 3 Half-Section of Fail-Safe Latching Barrier for Angular, Out-of-Plane S&A Layout



# XM784/ XM785 ET Fuze for Mortars

## *Explosive Train*

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- **Utilized explosive experts**
  - Generated a matrix of possible candidates
- **Identified a possible on-shore source for black powder**
  - M10 to be considered as a replacement
- **Concepts to initiate black powder:**
  - Electric detonator or primer initiates powder directly
  - Electric match initiates intermediate chg (environmental stability a concern)
- **Conduct explosive tests with candidate initiators**



# **XM784/ XM785 ET Fuze for Mortars**

## *Packaging and Hand Setting*

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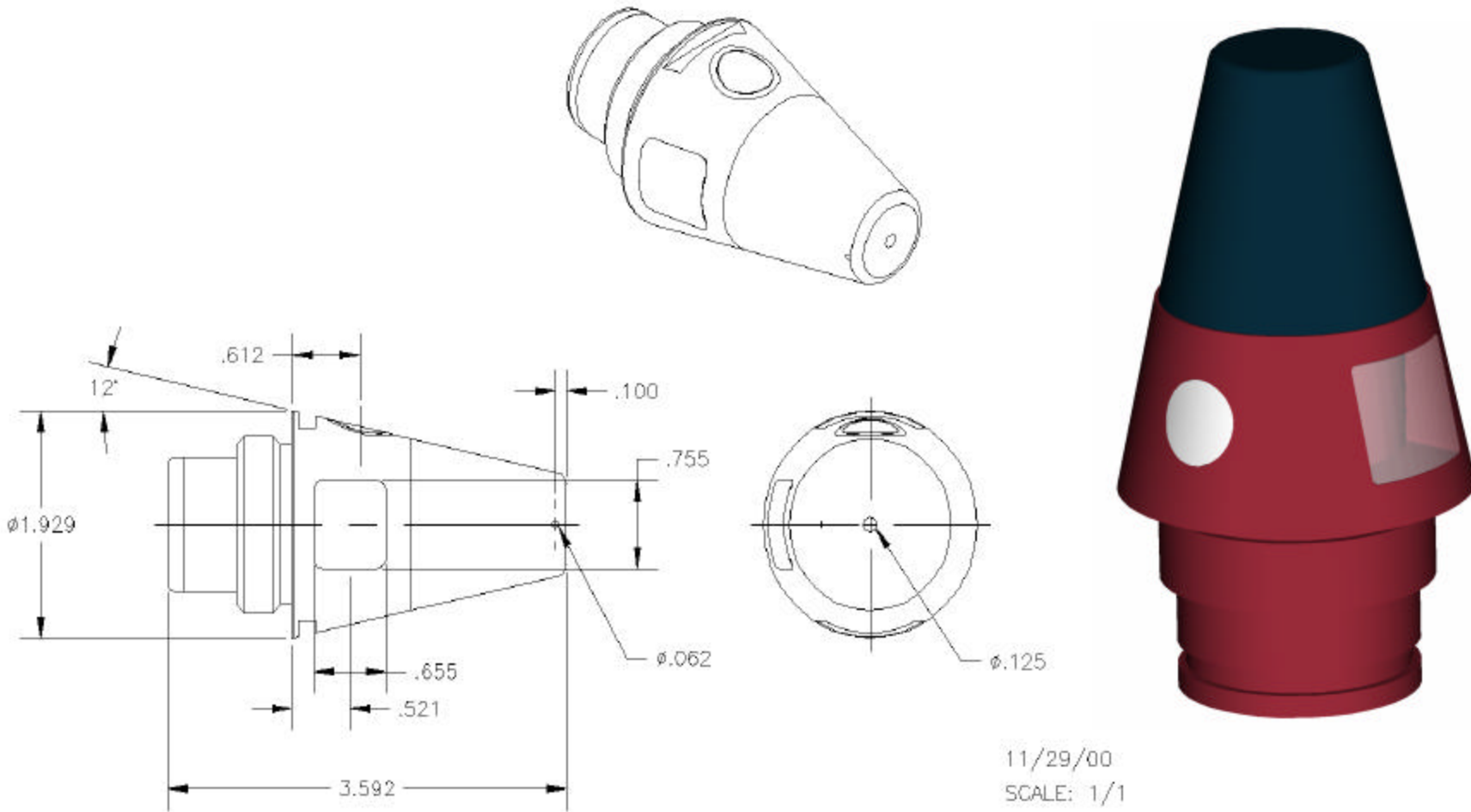


- **Generated Packaging Layouts**
  - Vertical and Horizontal Circuit Boards
  - Utilizing flex circuit concept
- **Handset scheme similar to M762**
- **Used NDI / custom LCD's (M762 Based)**
- **Developed a PRO-E model**
  - Handset concept (SLA prototype)



# XM784/ XM785 ET Fuze for Mortars

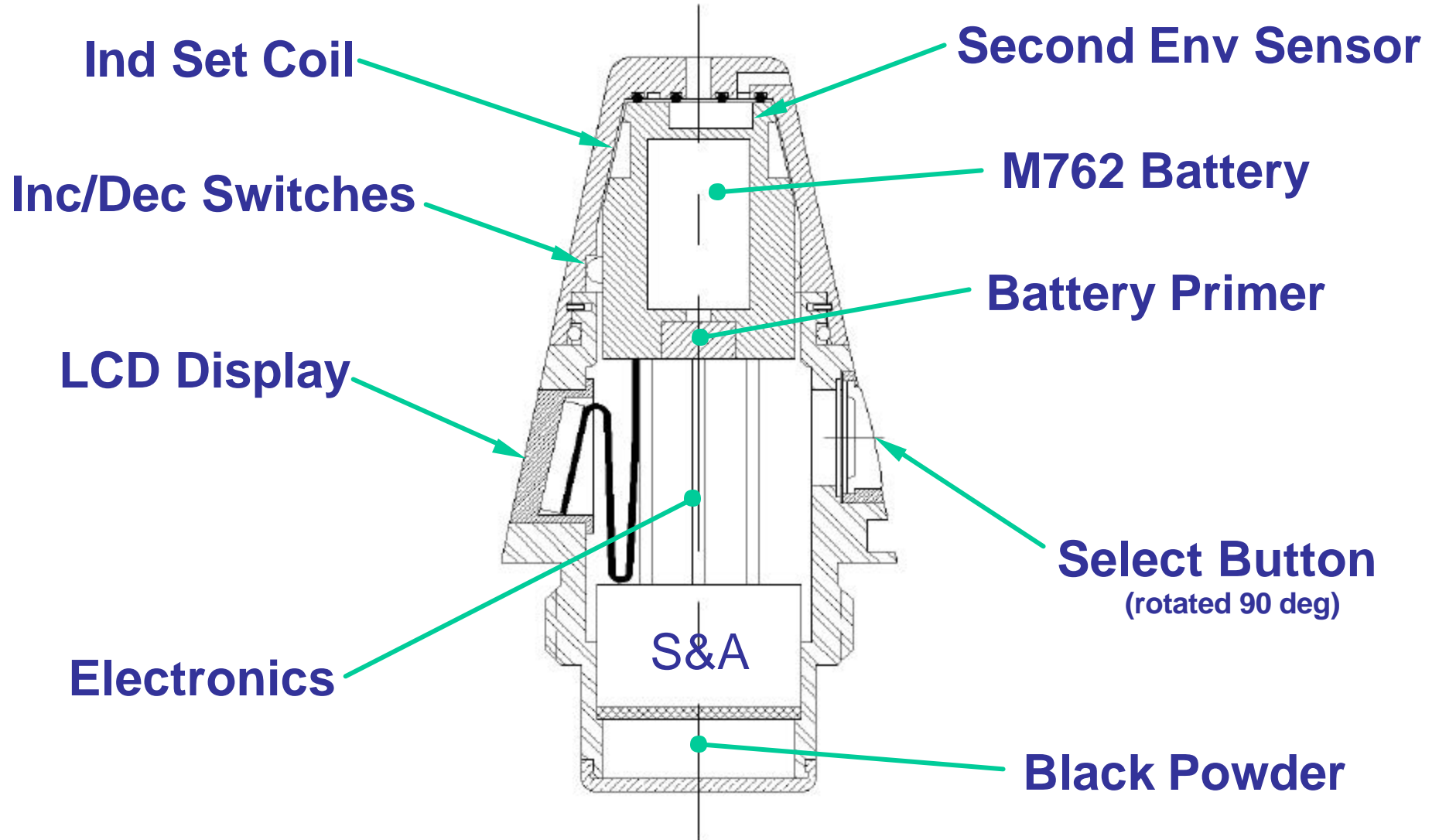
## *Packaging Model*





# XM784/ XM785 ET Fuze for Mortars

## *Packaging Concept*





# XM784/ XM785 ET Fuze for Mortars

## *Summary*

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- Planning Contract Award In June 2001
  - Design & Development
  - Test & Type Classify
  - First Article & Materiel Release
- Developed Initial In-House Design Concept
- Will Use Best (Cost Effective) Design Approach
  - Proposed Contractor Solution
  - Government Design
- Gov't Electronics Design Approach Follows....