Multi-Option Fuze for Navy (Mk 437 MOFN)

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Fuze Navalization

Army

- "Navalize" the Army M782 Multi-Option Fuze for Artillery (**MOFA**) for use with the US Navy 5" Gun Weapon System
- Provide a moderately priced Multi-Mode of Operation Fuze for Naval Surface Fire Support & Surface Warfare Missions

Navy

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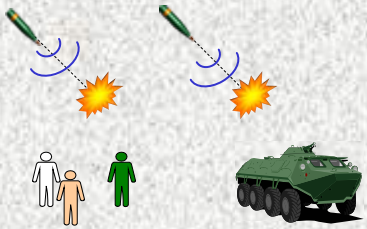
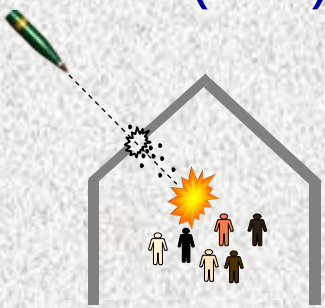
Navalization Approach

Retain MOFA Functional Modes:
Mk 437 MOFN = M782 MOFA

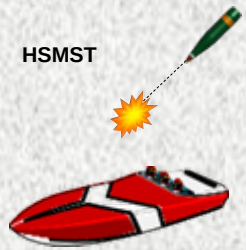
Surface Proximity (HOB)



Point Detonating Delay (DLY)



Electronic Time (ET)



Note: Navy will use ET Mode vs. HSMST

Point Detonating (PD)

Navalization Considerations

Army

Navy

Gun weapon system & mission changes

- PIAFS* ⇒ MK 34 Fuze Setter
- EMV: More Radiation to Deal with
- Safety & Qual Requirements different
- Different mission: close-in speed boats

*PIAFS = Portable Inductive Artillery Fuze Setter

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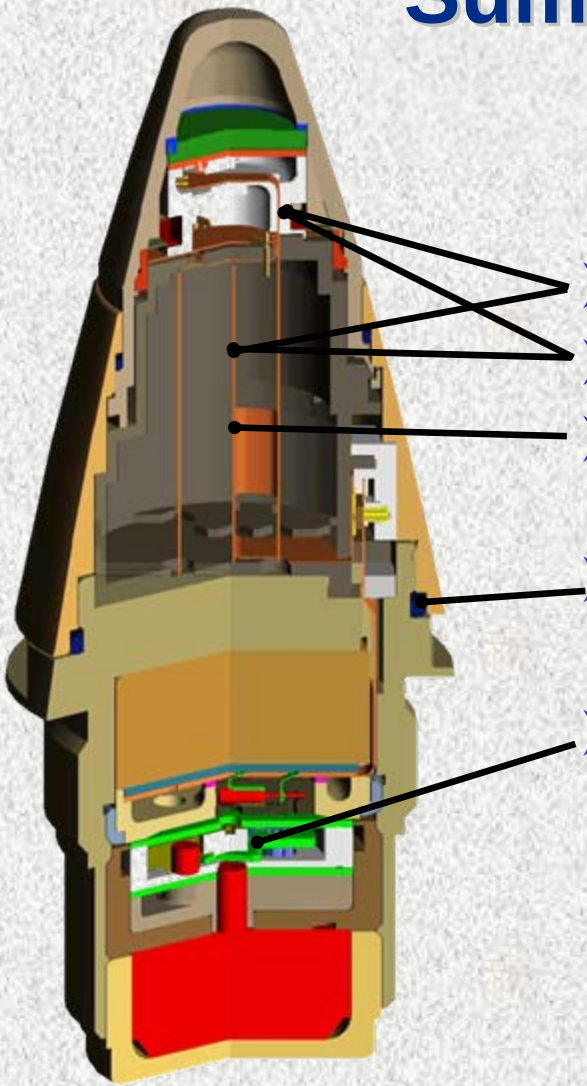
Overview of Changes

Summary of Engineering Changes (none went as planned)

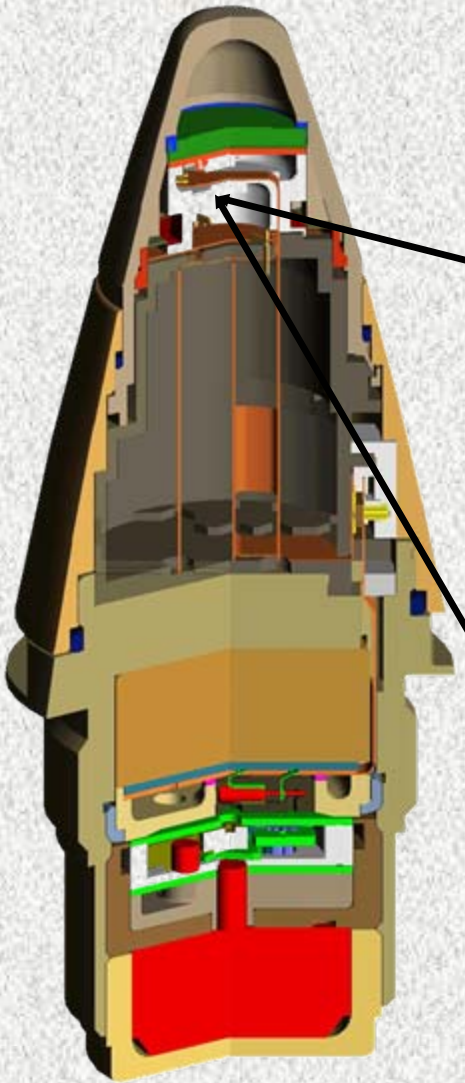


- Changes To Inductive Interface Hardware
- Unexpected Electronics EMV Hardening
- Changes To Fuze Software
  (Unexpected Complete Software re-write)
- Unexpected Improvement to fuze seals

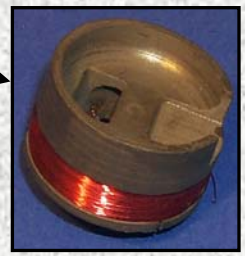
- Changes To Safe & Arm Device Explored
  (Unmodified S&A determined to be sufficient after much mechanical design, test & safety analyses)

Required Engineering

Inductive Interface Changes



Initial Engineering Design Approach up to PDR:



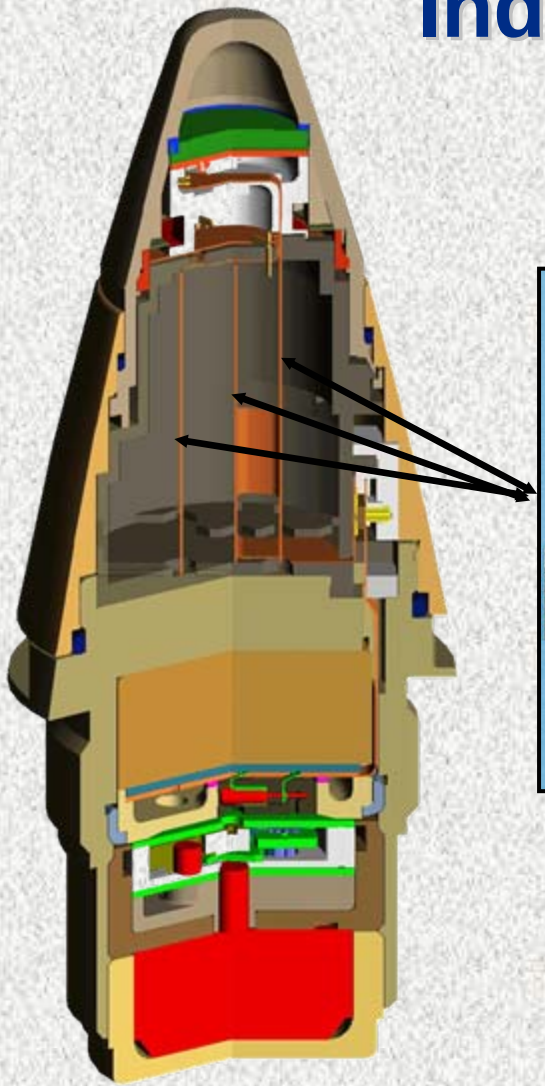
- Bobbin made of Magnetic Material
- ~ twice the number of windings
  - smaller gauge
- Magnetic Material could not be manufactured

Final Engineering Design Approach:

- Same bobbin as MOFA
- Same # coil windings
- Added Magnetic Core

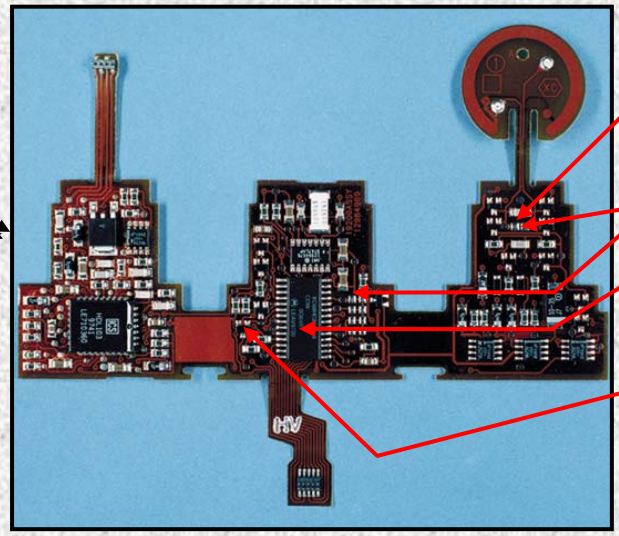
Required Engineering

Inductive Interface Changes (cont.)



Final Engineering Design Approach:

- Minor Changes to Electronics:



- Changed inductive tuning components
- New Flex Card Layout
- Changes to Pin assignments
- Different Voltage Detector

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Required Engineering

Software Development

- Complete re-write of **MOFA** software
- Object Oriented Design
- 95% High-level language (5% assembly code)
- Development based on IEEE/EIA 12207.1 &.2
- Hardware in the loop prototype & Qualification testing (G34 & EDC)
- Performed Independent Software Safety Analysis (EG&G)

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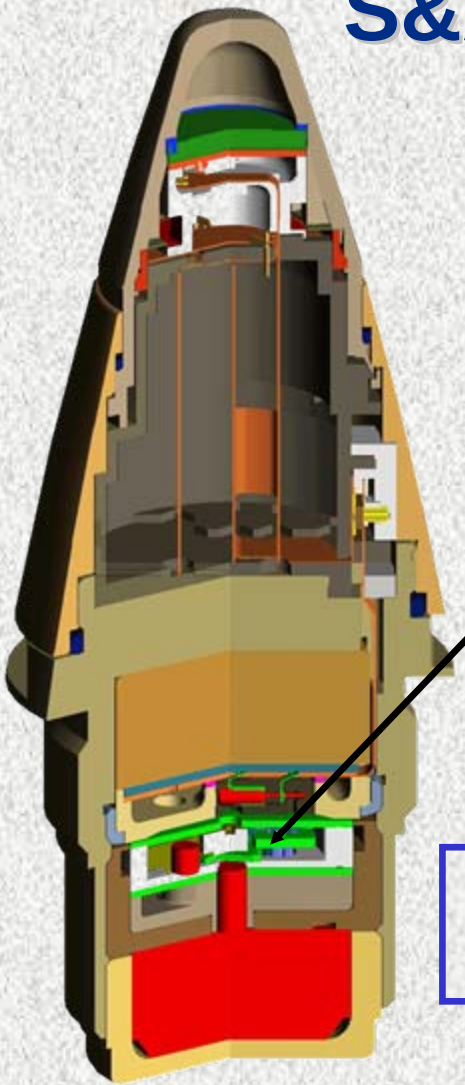
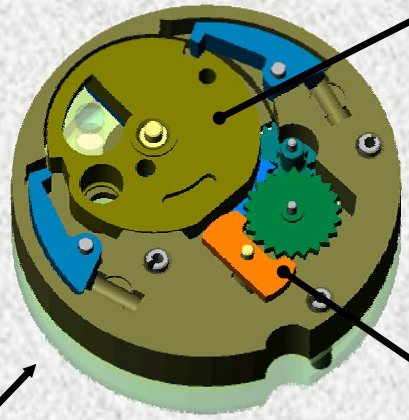
Required Engineering

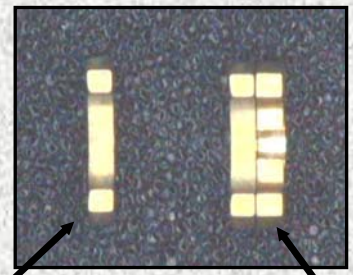
S&A changes explored





Standard MOFA Rotor

MOFN Rotor: 3 holes drilled



Standard MOFA Pallet

MOFN Double Thick Pallet

- Achieve > 420 ft Min Arming Dist. (AVG - 3σ)
- Reliability Gunfire Test resulted in 19/22 successful

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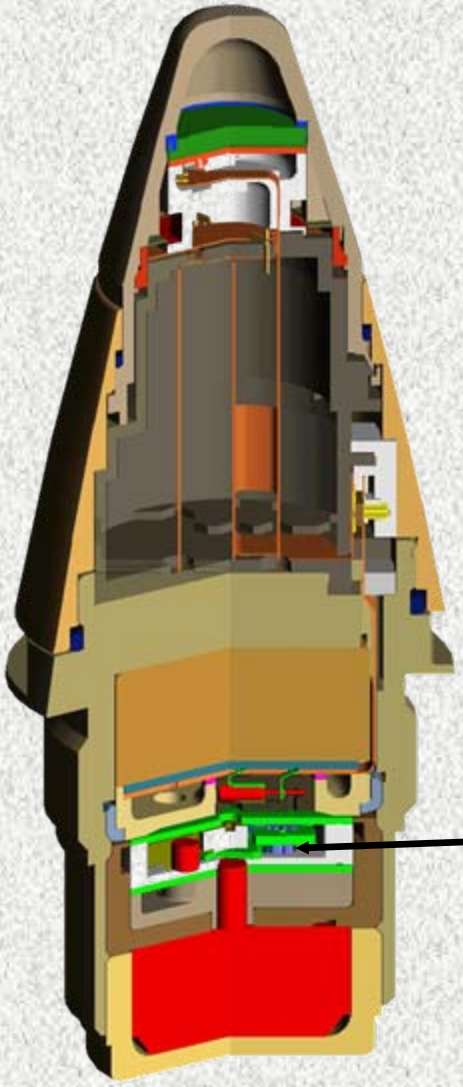
Required Engineering

S&A changes explored



- **Reliability issues with extended arming distance**
- **Safe Separation Analysis indicates that unmodified MOFA S&A will satisfy safety requirement**
- **MOFN S&A Modification abandoned**
  - Unmodified MOFA S&A will be used on MOFN

Use Unmodified MOFA S&A

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Schedule

- PDR (Nov 2004)
- Lot A Test (20 Gunfired – Jan 2006)
- Lot B Test (349 fuzes – July 2006)
- Lot C Test (50 fuzes – Aug 2007)
- Award LRIP (Oct 2007)
- At-Sea Shipboard test (June 2008)

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MOFN Lot A Results

- **Test Results**
  - ET met specification
  - HOB over water did not meet specification
    - 8/15 functioned below the minimum HOB
    - Bi-modal HOB ~5’ & ~40’
  - Gross Leak Testing results did not meet specification

Investigated failures, made fixes, built Lot B

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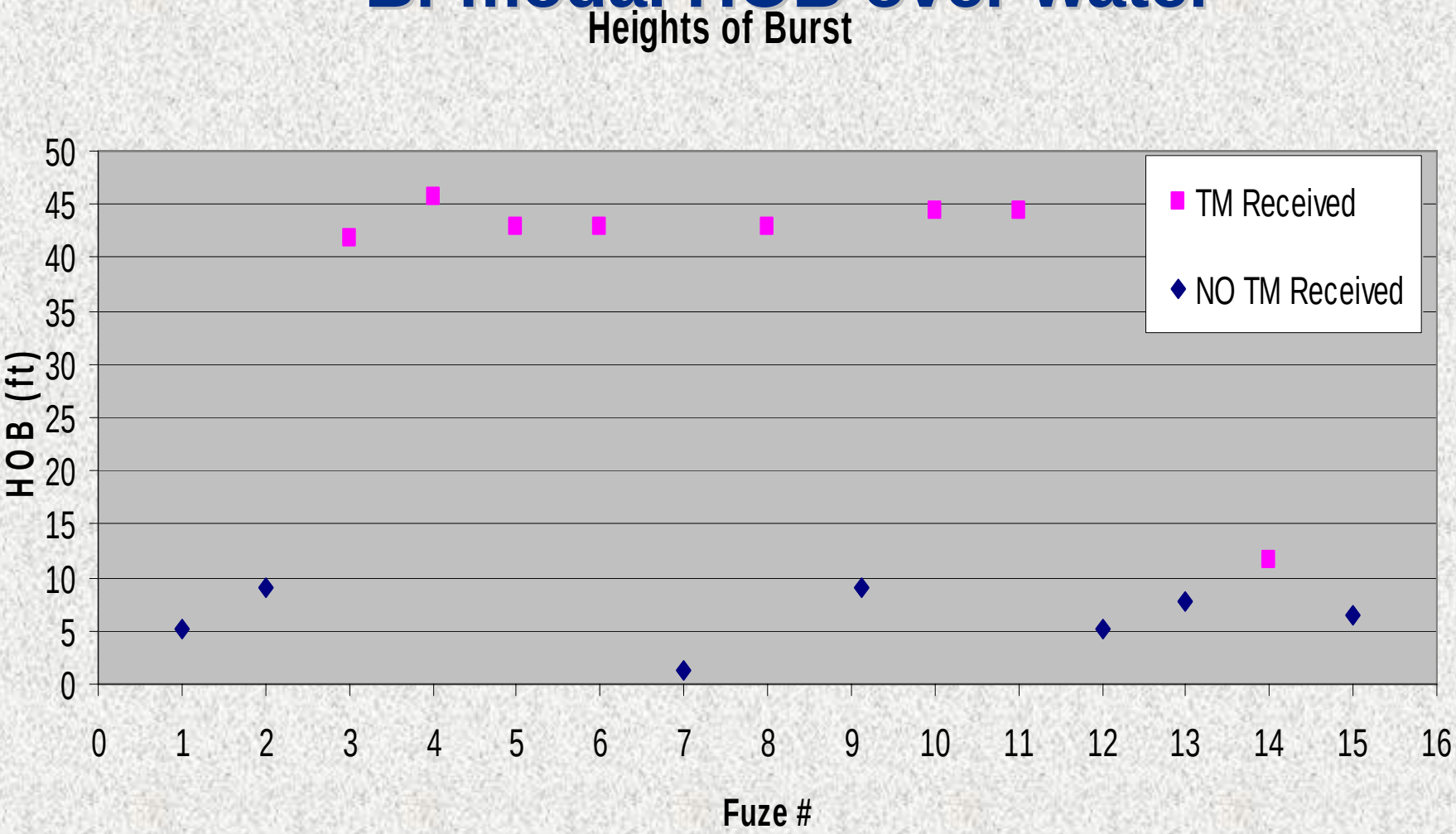
MOFN Lot A Results

Bi-modal HOB over water



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Lot A Bi-modal HOB Issue

- Root Cause Investigation Performed
  - Root Cause Panel consisted of representatives from Navy, Army, KDI and EDC
  - 24 Potential Root Causes were identified
- Over land tests did not show same bi-modal response
- Army has never seen bi-modal response in MOFA testing
- Lot B testing did not show bi-modal response
- Phenomena remains unexplained

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MOFN Lot B Results

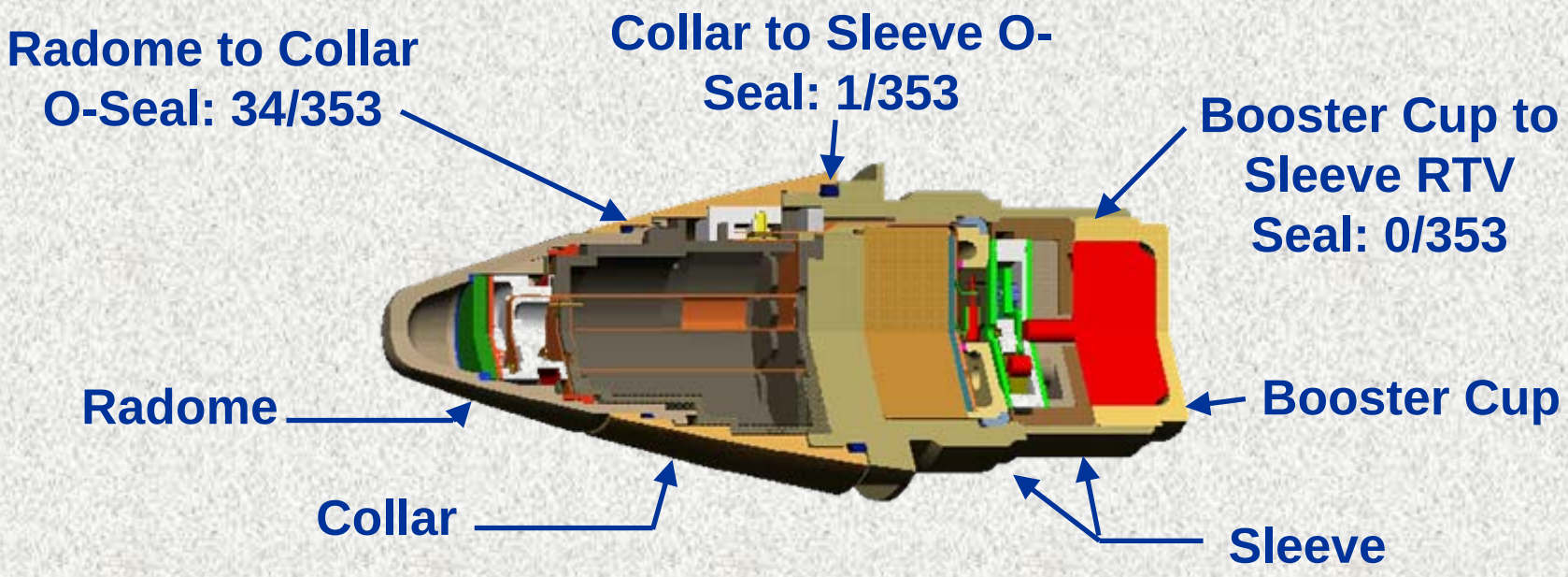
- **Test Results**
  - MIL-STD-331 tests
    - Gross Leaks
  - Ballistic Tests in ET, PD, & HOB modes
    - Duds
    - Prox failures (PD instead of HOB & no TM)
  - Passed E3 testing

Investigated failures, renegotiated contract, continuing investigation prior to building next lot

Lot B - Leaks

- **10% Fail Gross Leak Test**

MOFN Seal Locations with # Occurrences of Leaking During Lot B Qual Build Leak Tests



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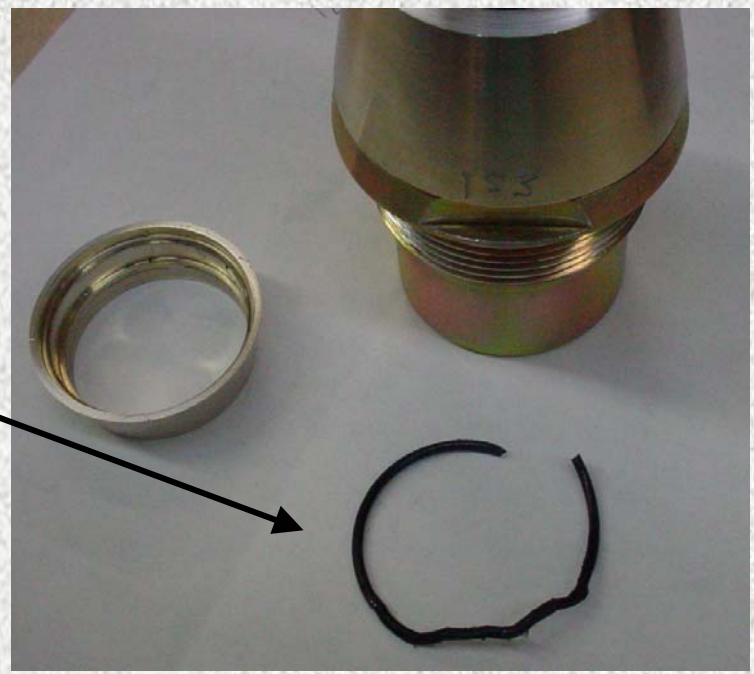
Lot B - Leaks

Radome to Collar O-Seal Damage

Collar Cut completely through to reveal O-Seal without disturbing it.

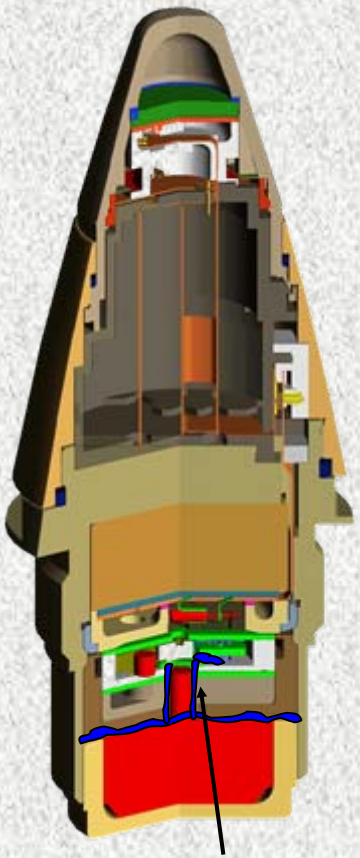
O-Seal



Inspection shows that O-Seal was Damaged in installation process

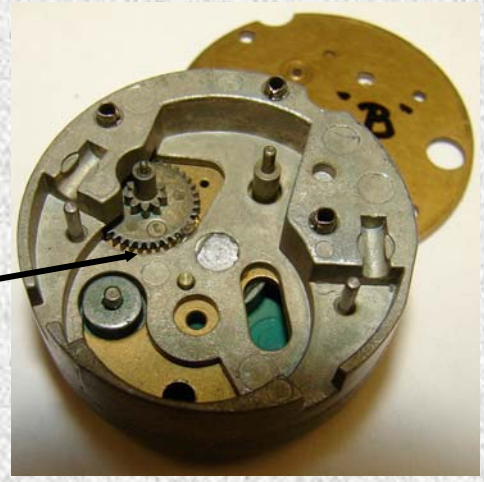
Lot B - Duds

- Change to method of sealing Booster cup lead to failures.
  - Lot A – RTV applied to top threads and was blown out by pressure as booster screwed in.
  - Lot B – RTV applied to bottom to prevent this.
- Too much RTV squeezed into S&A and seized S&A creating a dud.



As Lot B Booster cup is screwed in- Excess RTV is forced up into the S&A

RTV on S&A Gears



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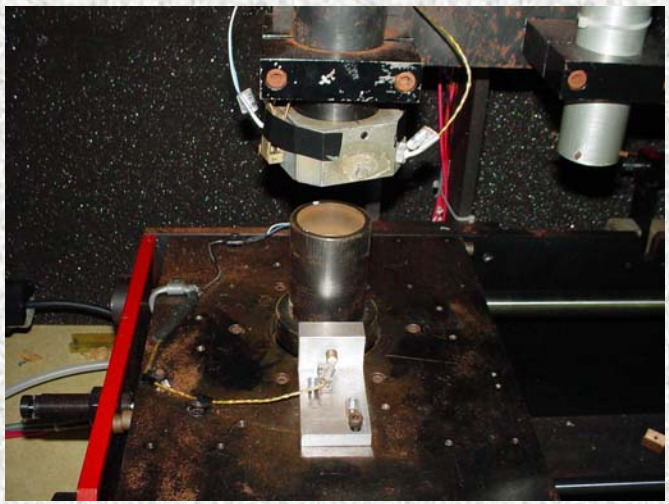
Lot B – Prox failures

- Failure analysis conducted by KDI
  - Ferrite Core possibly cutting Transceiver Flex Circuit during gun launch
  - Spin drop tests to test this possibility
  - 2 of 10 had cut circuits
- Solutions: Key ferrite core to prevent rotation



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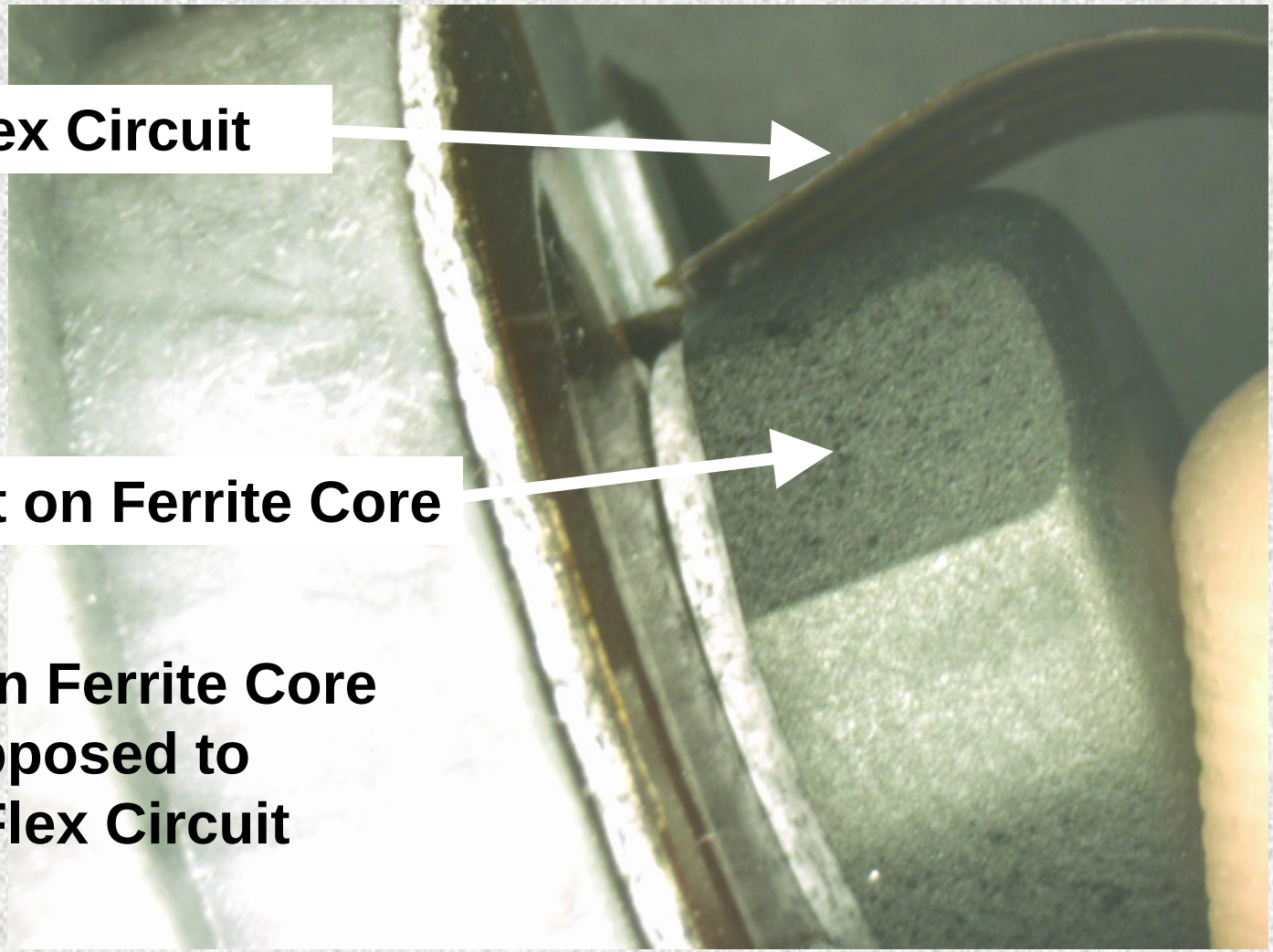
MOFN Lot B - Prox Failures



Flat on Ferrite Core is supposed to face Flex Circuit

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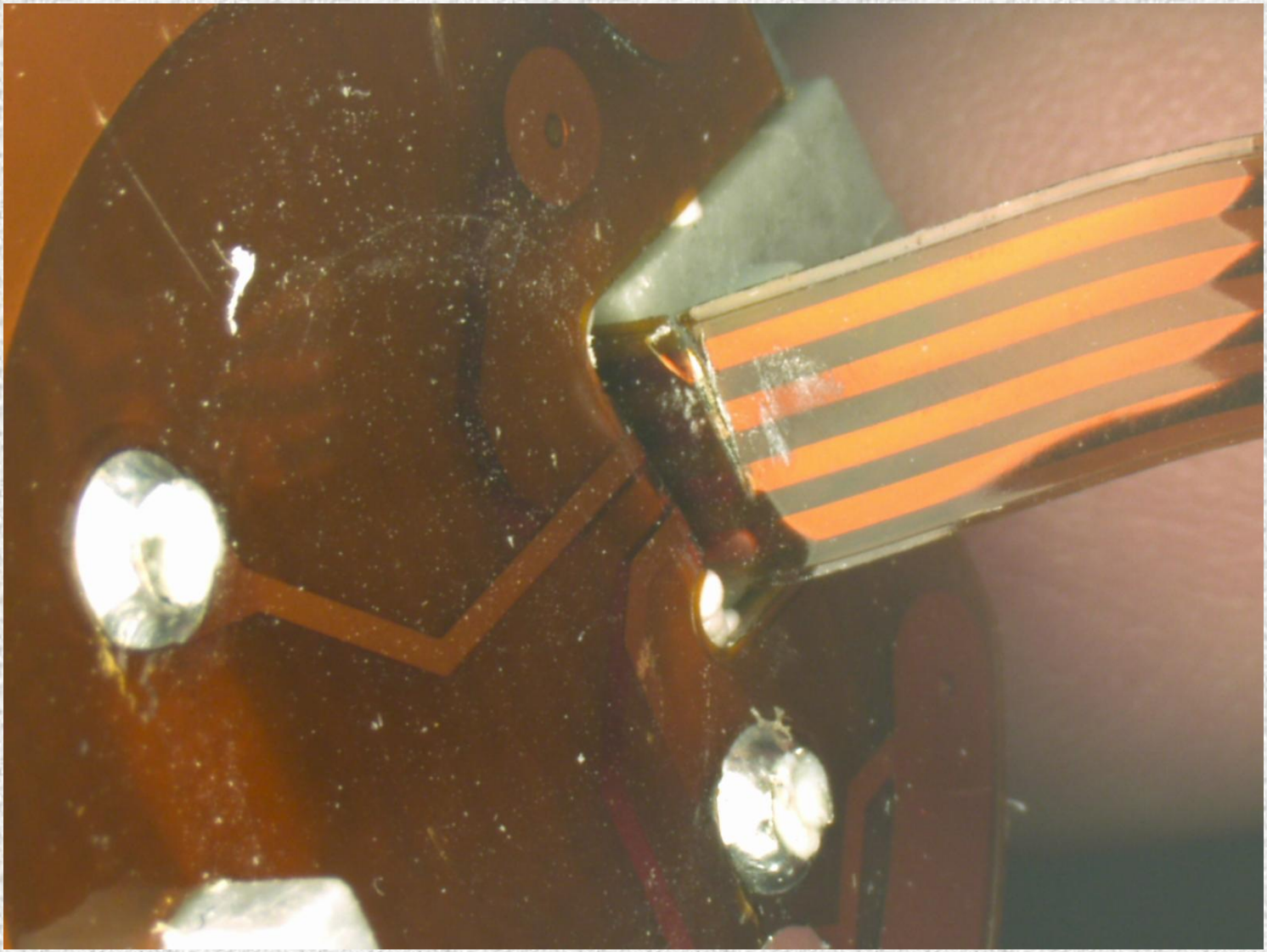
MOFN Lot B - PROX Failures



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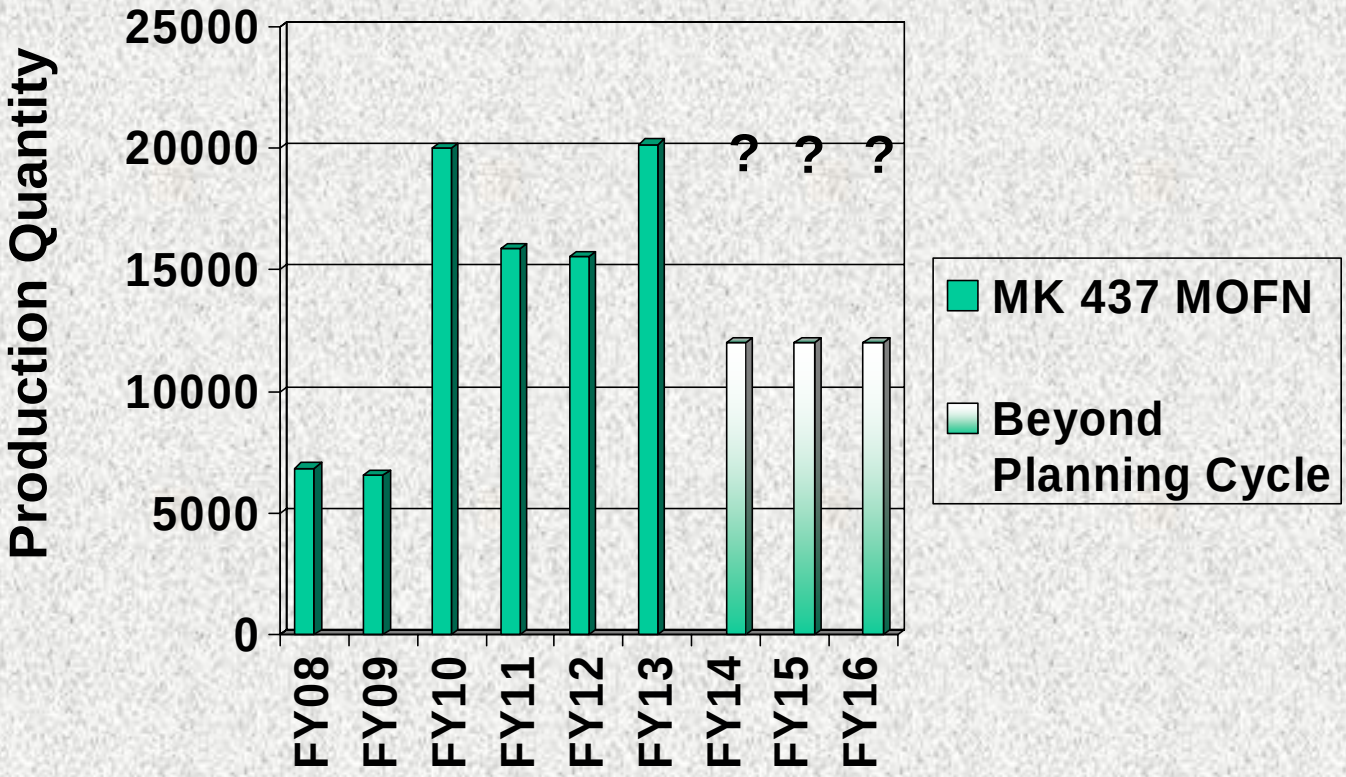
MOFN *Planned* Procurements

(No guarantees)



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Multi-Option Fuze for Navy (MOFN)

- Conclusion
  - Mk 437 MOFN is on track to meeting the Navy's requirements for an affordable multi-mission fuze this FY

For Further information:
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