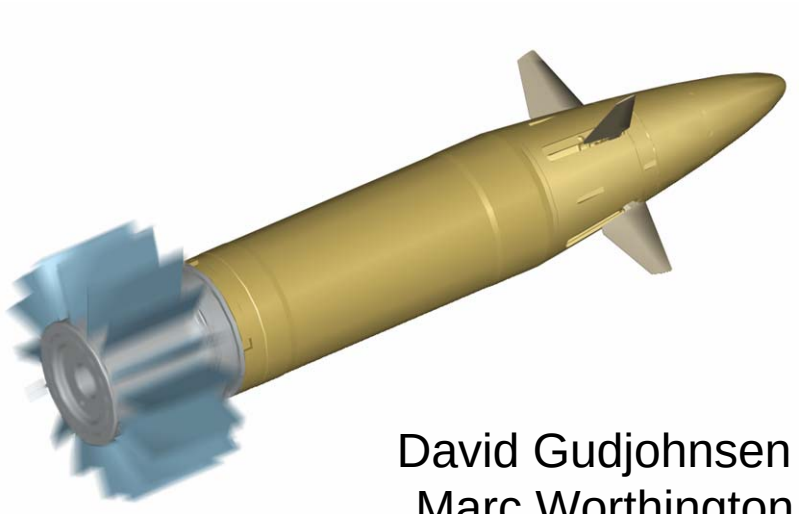
Development of the XM982 Excalibur Fuzing System



David Gudjohnsen -ARDEC
Marc Worthington -L3 KDI

NDIA 49th Annual Fuze Conference 5-7 April, 2005

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AGENDA

- Program Background
- System Overview
- Key milestones
- Concept of Operations
- Fuzing (FSA) System Overview
- Mechanical FSA features
- Electronic FSA features
- Events timeline
- System block diagram
- Testing
- Key Design Changes
- Analyses
- Summary

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Background

- System Development and Demonstration(SDD) commenced in Jan 98
- Dec 02 – U.S Army & Kingdom of Sweden issued contract to merge XM982 with Trajectory Correctable Munitions(TCM) program
- Program managed by PM Excalibur, PM Combat Ammunition Systems (PMCAS), Program Executive Officer for Ammunition (PEO AMMO) , Product manager: LTC William Cole, Picatinny Arsenal
- Contract Team (Payload and Fuze IPT related)
  - Raytheon Missile Systems (RMS) – Prime contractor
  - Bofors Defence – Projectile and system engineering
  - General Dynamics OTS –Unitary payload and projectile body
  - L3 KDI Precision Products – Fuze, safe and arm/ Height of Burst sensor

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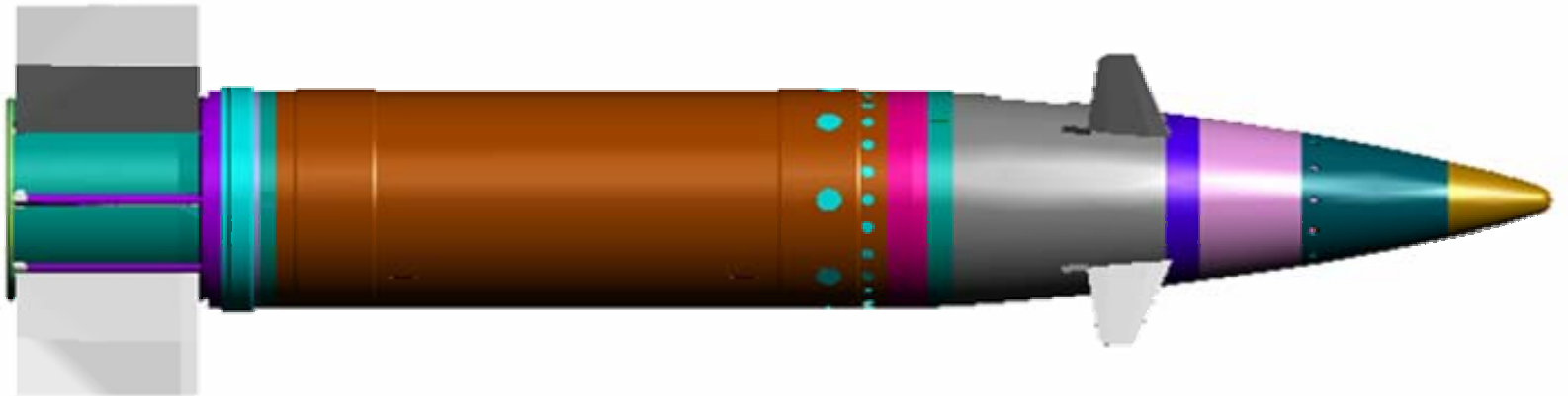
System Overview



Characteristics/Description:

- 155MM Extended Range guided projectile
- Fin Stabilized Glide Air Frame
- Inductive Set with Enhanced Setter
- GPS - Inertial Navigation System (INS) Guidance
- All Weather, Day and Night
- Compatible with JLW155 & FCS Digitized 155mm Platforms
- One Meter Length / 106 lb

- Current program: SDD unitary
- Accuracy: 10MCEP objective
- Range: 40Km objective
- Targets : Personnel, light materiel, structures
- Fuze modes: PD, PD delay, Prox
- Environments:
  - 15.5 KG set back
  - 50+ KG penetration

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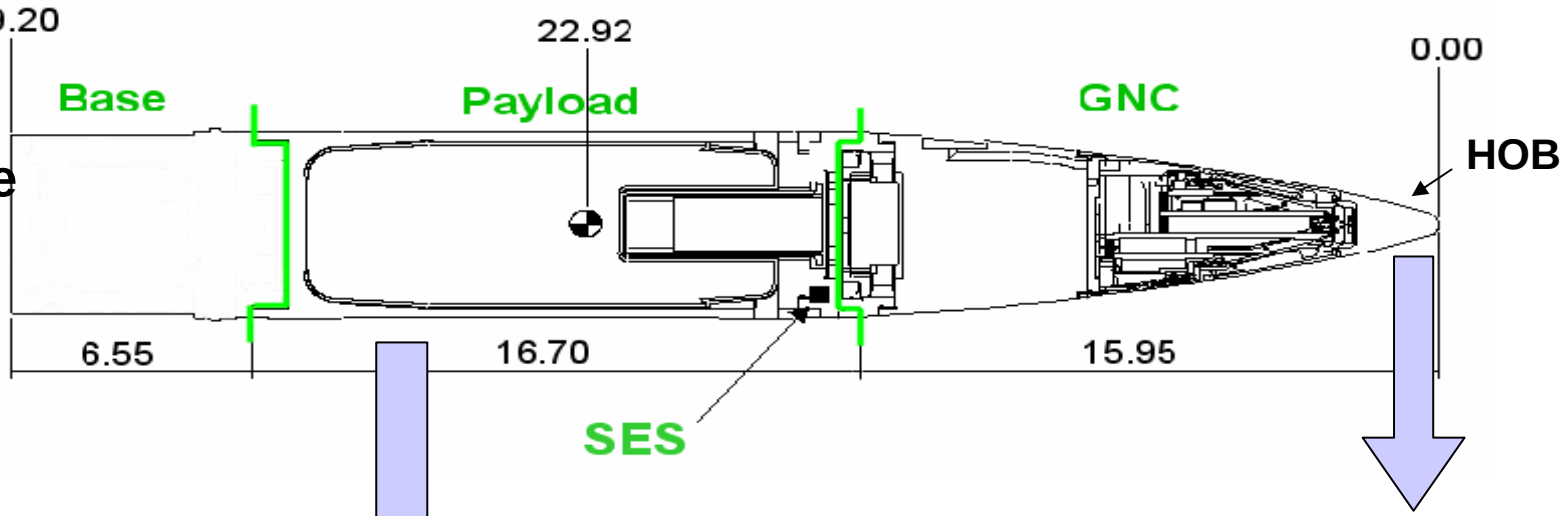
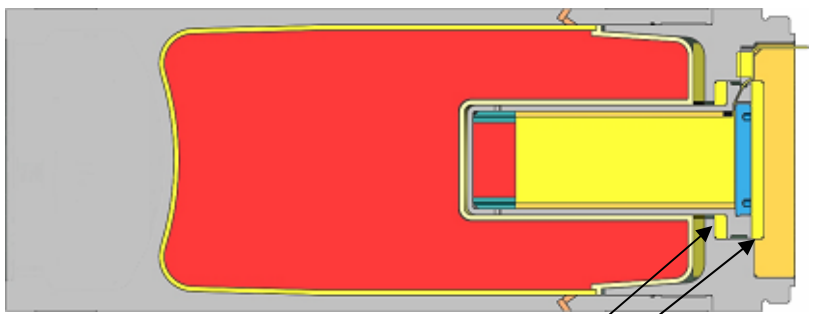
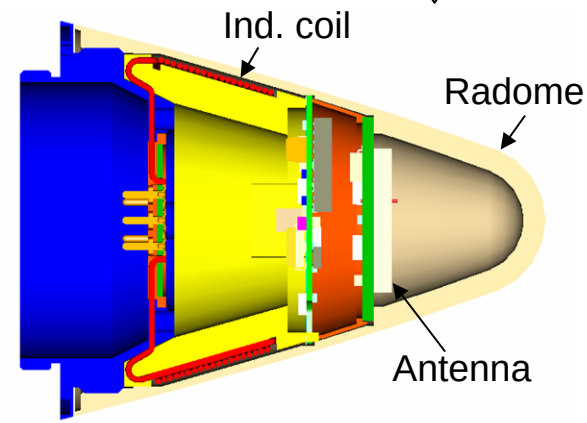
Excalibur System

Blk I Unitary Baseline





Damping Material
(Gunlaunch & Penetration env)



- **Production fuze Prox sensor chipset**
- **Burst Height of 3.7 +/- 1 meters**
- **Point Detonate Backup**
- **Unpowered until 3.5 seconds from target**

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Key Milestones

- System Development and demonstration (SDD) unitary projectile Dec 02 - present
  - System CDR - 3Q FY05
  - Firing train end to end – 4Q FY 05
  - Safety Test Series – 4Q FY05
  - Guided gunfire (GGB) – 4Q FY05
  - End to End Demo – 1QFY06
- MSC (Initial capability) completed by FY06
- Full Initial Operational Capability FY08

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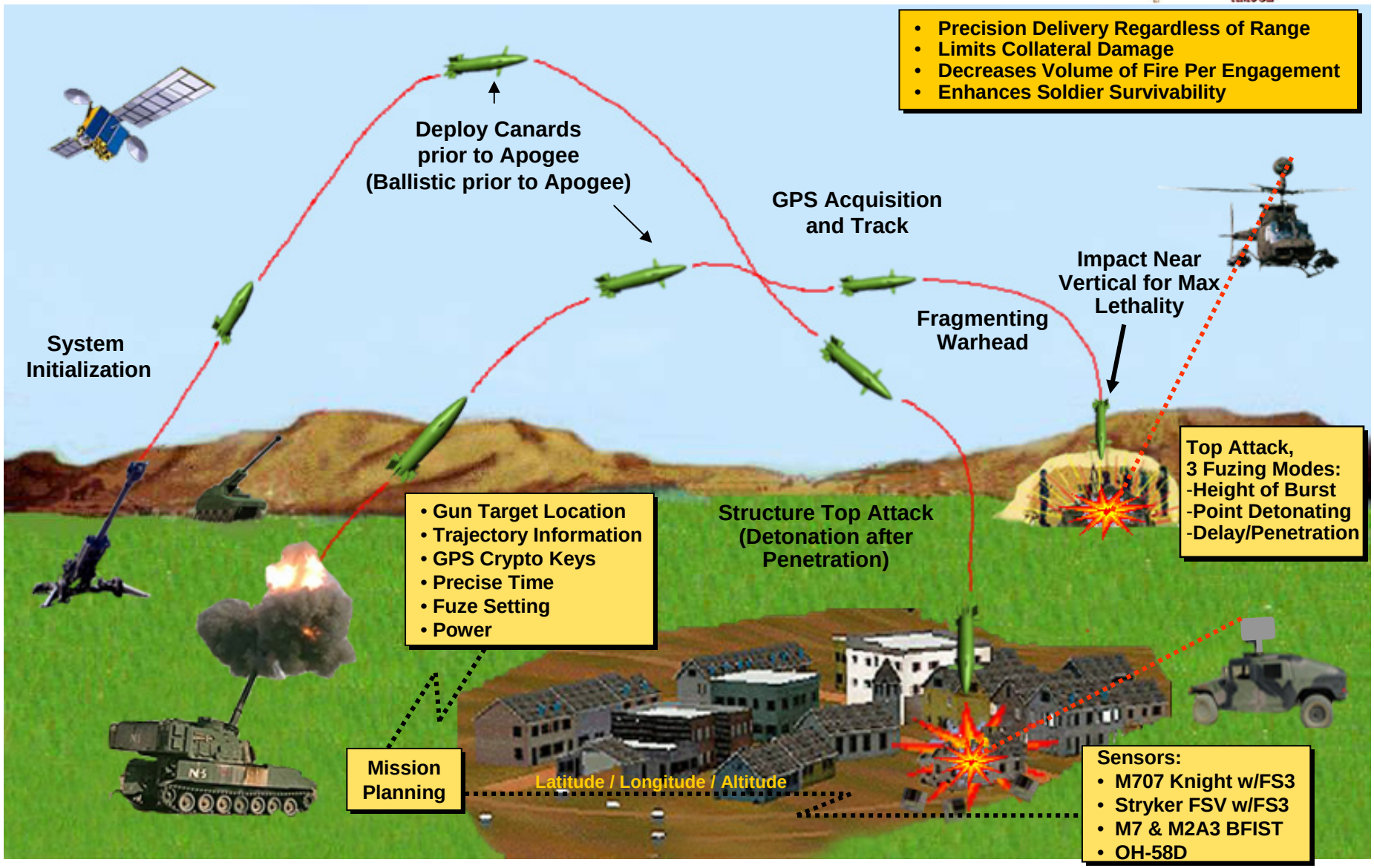
Concept of Operations

EXCALIBUR XM982



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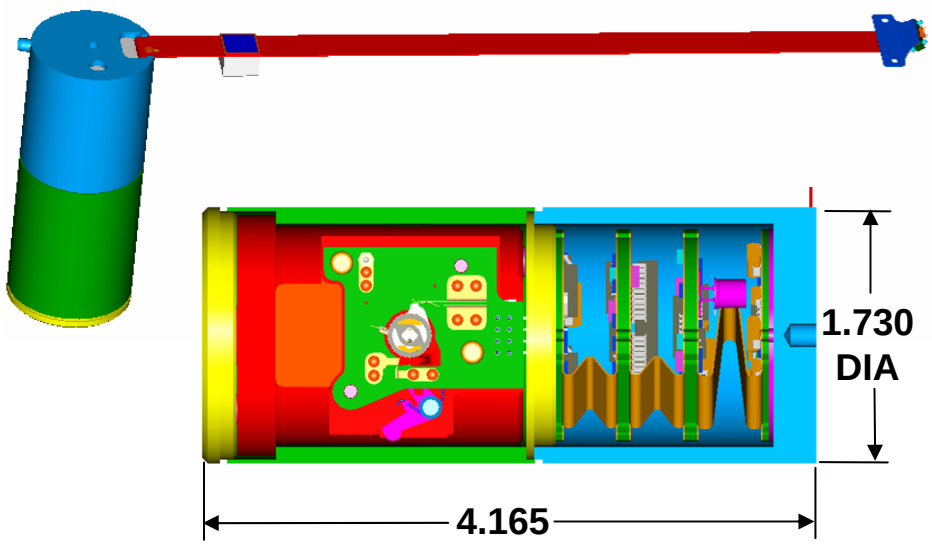
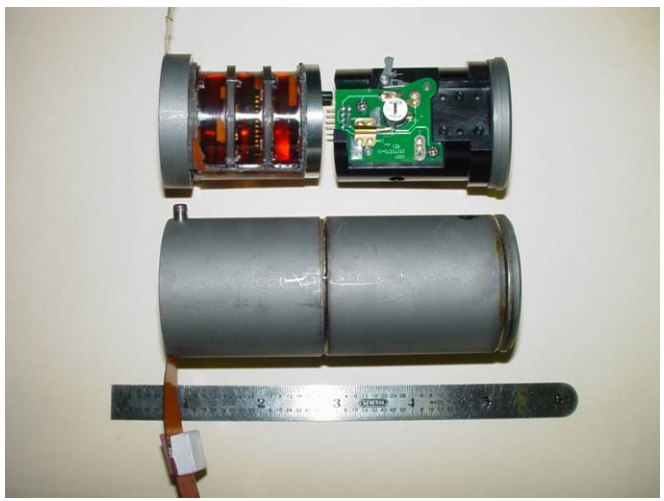
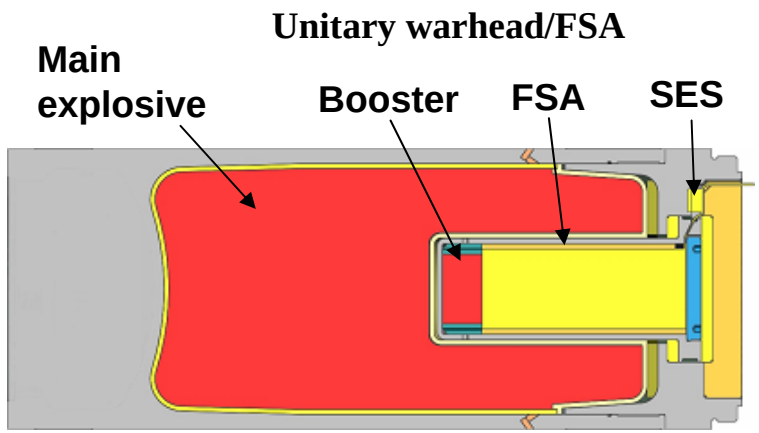
Fuze Safe & Arm (FSA)



Key Features

- FSA consists of electronics module and mechanical module
- First Arming Environment is setback acceleration implemented mechanically
- Second Arming Environment is detection of de-spin event using a “g” switch
- Safe separation via independent timers
- Point Detonate fuze is implemented by a g-switch opening at impact.
- Delay after Point Detonate implemented by electronic timer
- HOB function implemented by RF proximity sensor using production fuze components
- L3 KDI Subcontract





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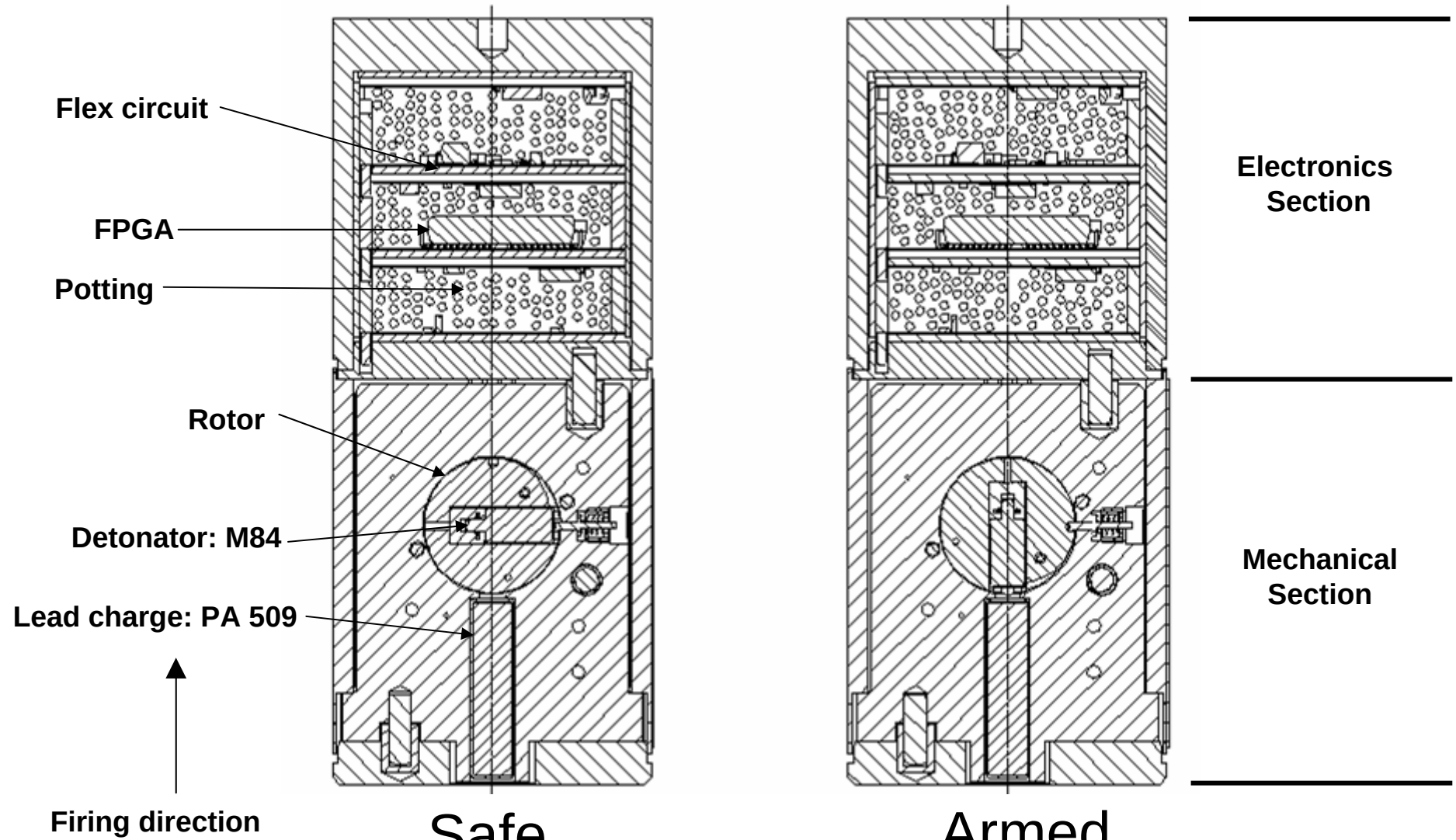
FSA FEATURES



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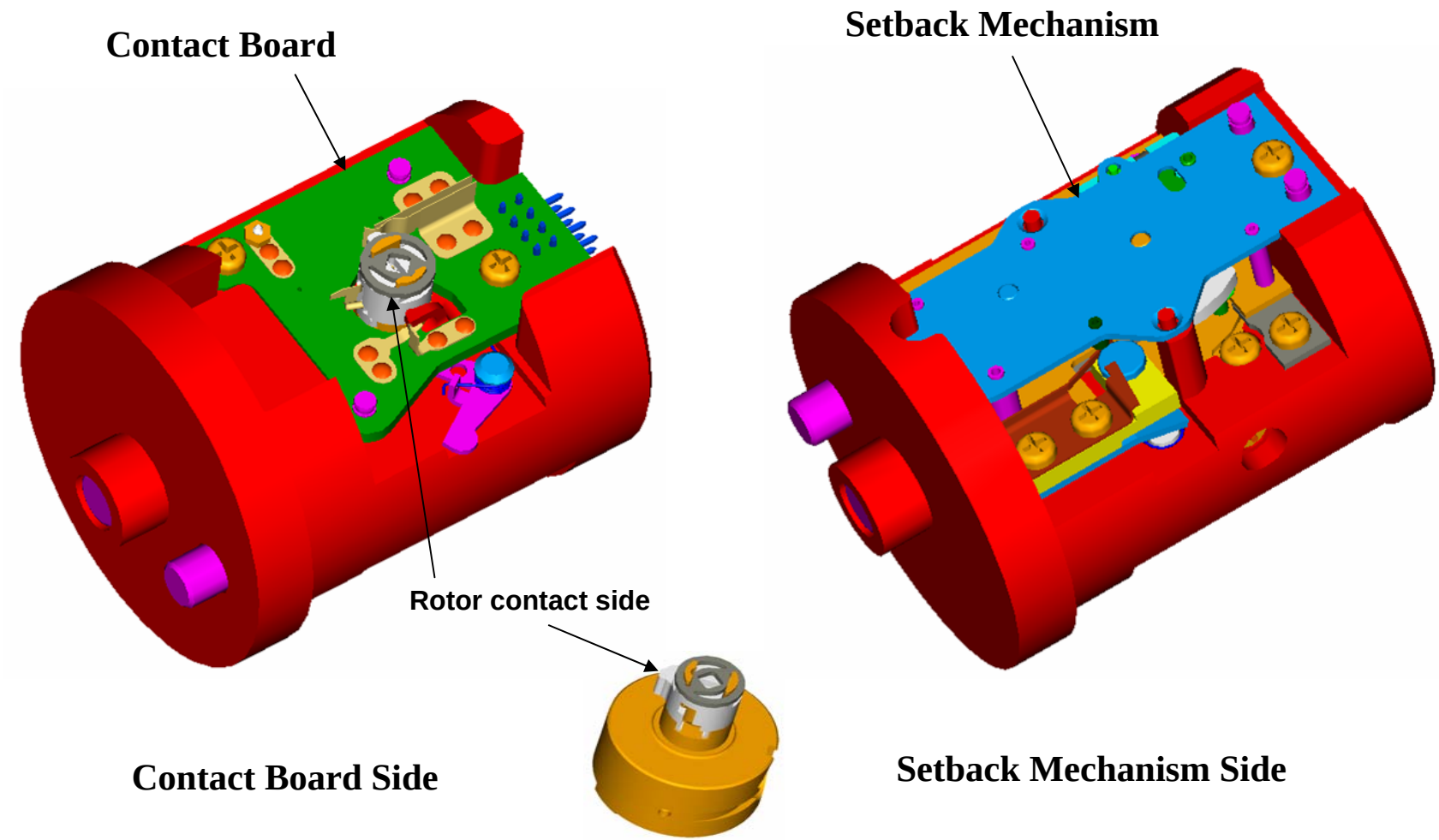
Mechanical S&A



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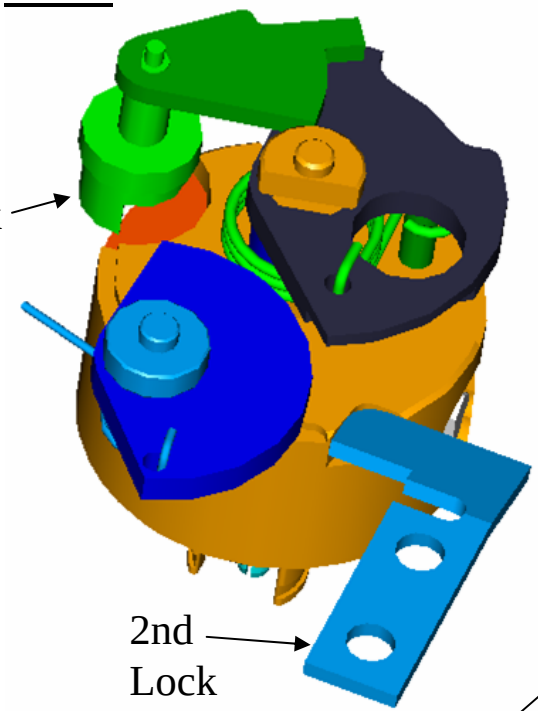
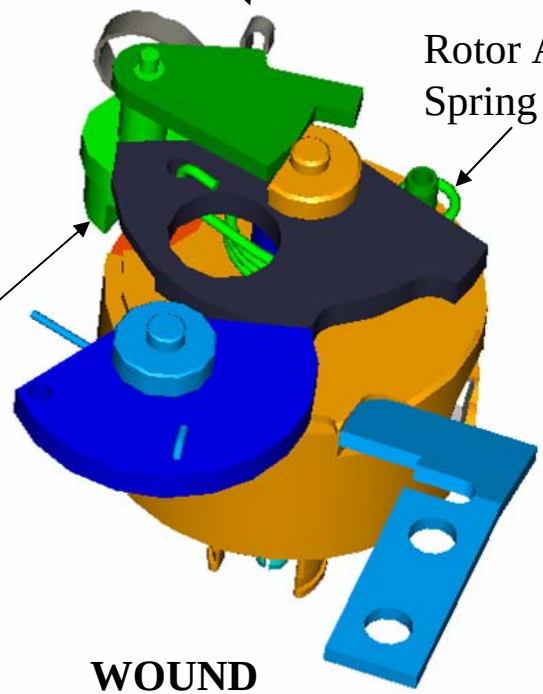
Mechanical S&A, Safe, Wound and Armed

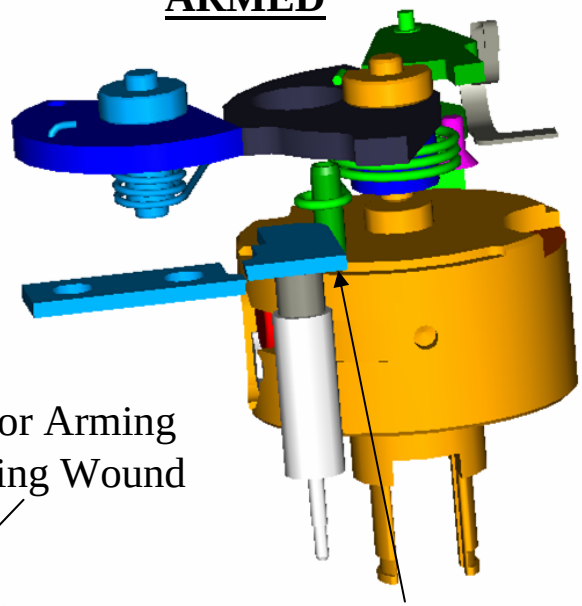
SAFE



WOUND



ARMED



No go – 300g
All go –1250g

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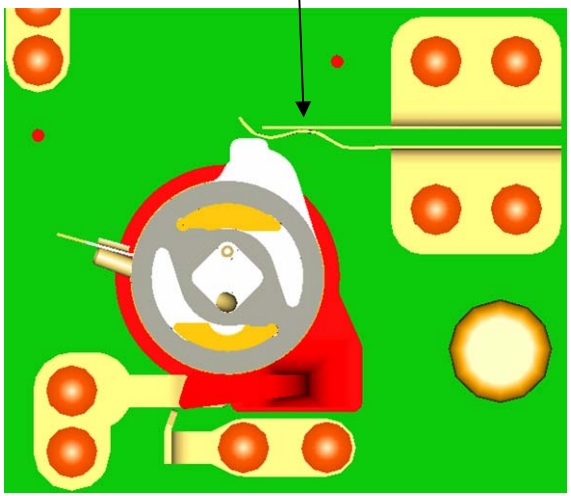
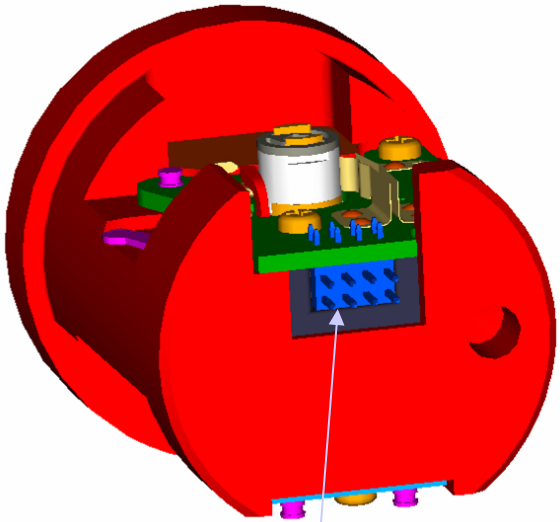
Mechanical S&A, Contact Board

SAFE

Status Contacts Closed

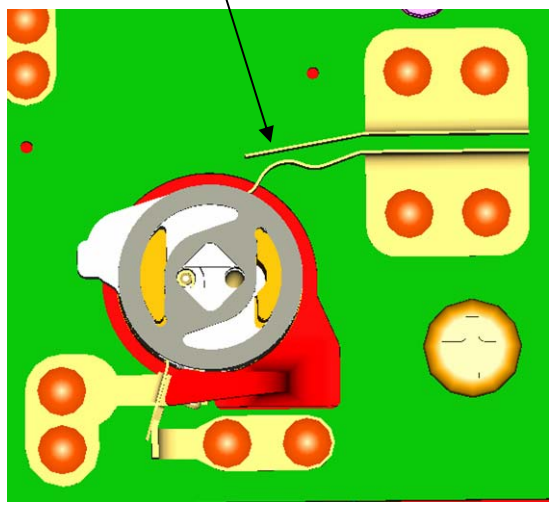


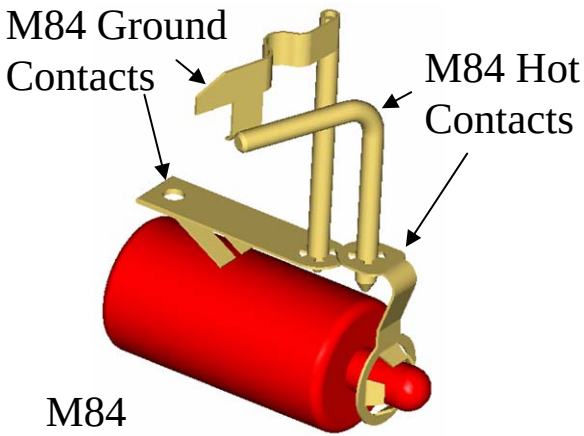


Connector for Interface with Electronics

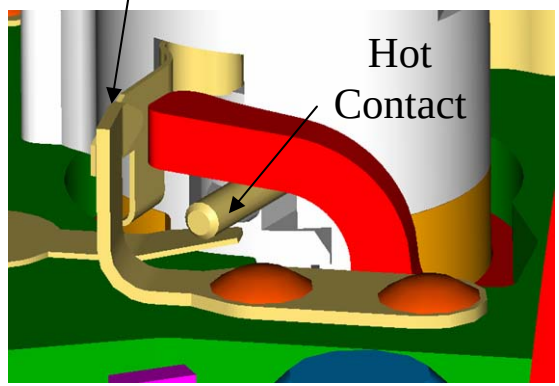
ARMED

Status Contacts Open





Ground Contact



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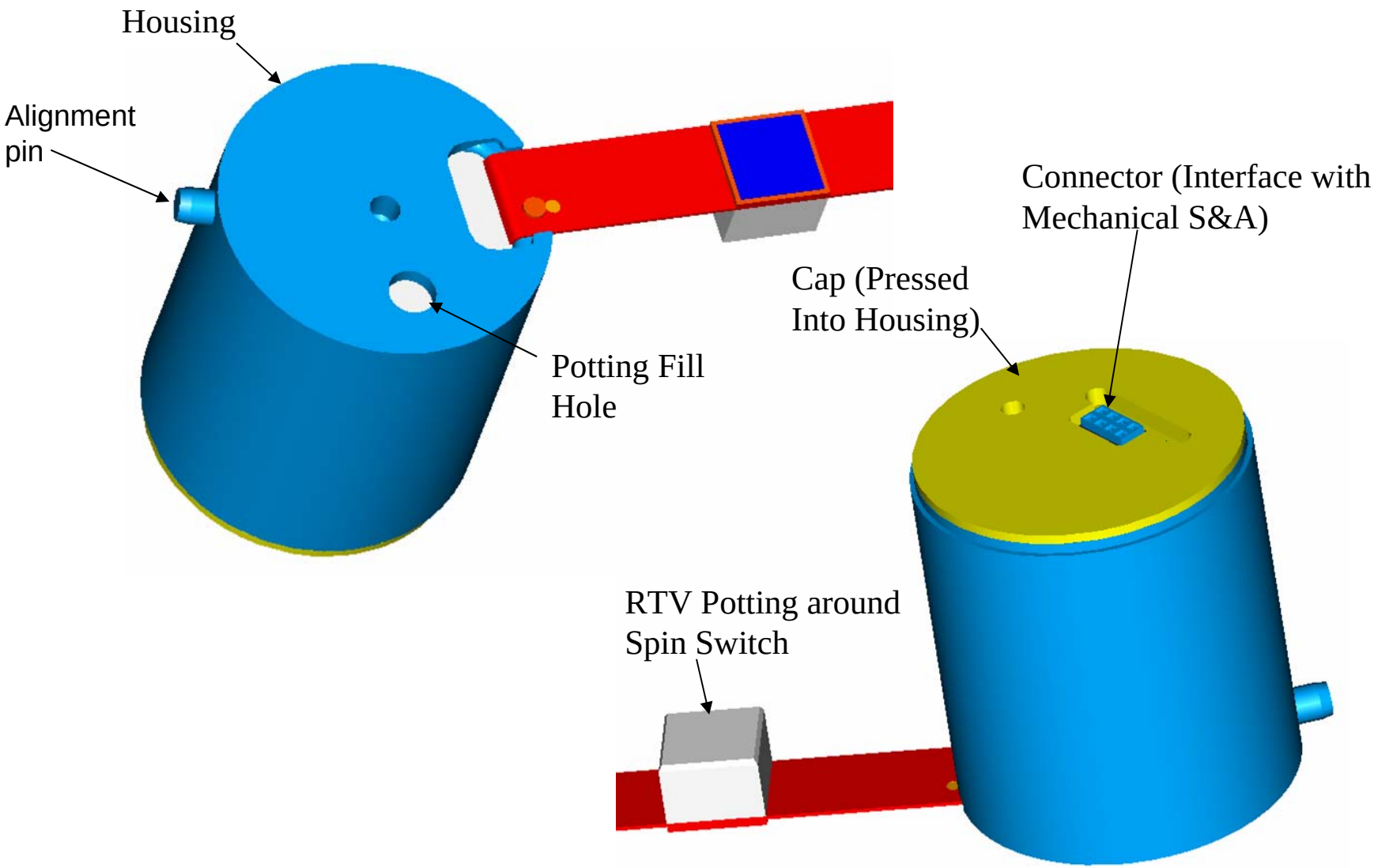
FSA Electronic Sub-Assembly



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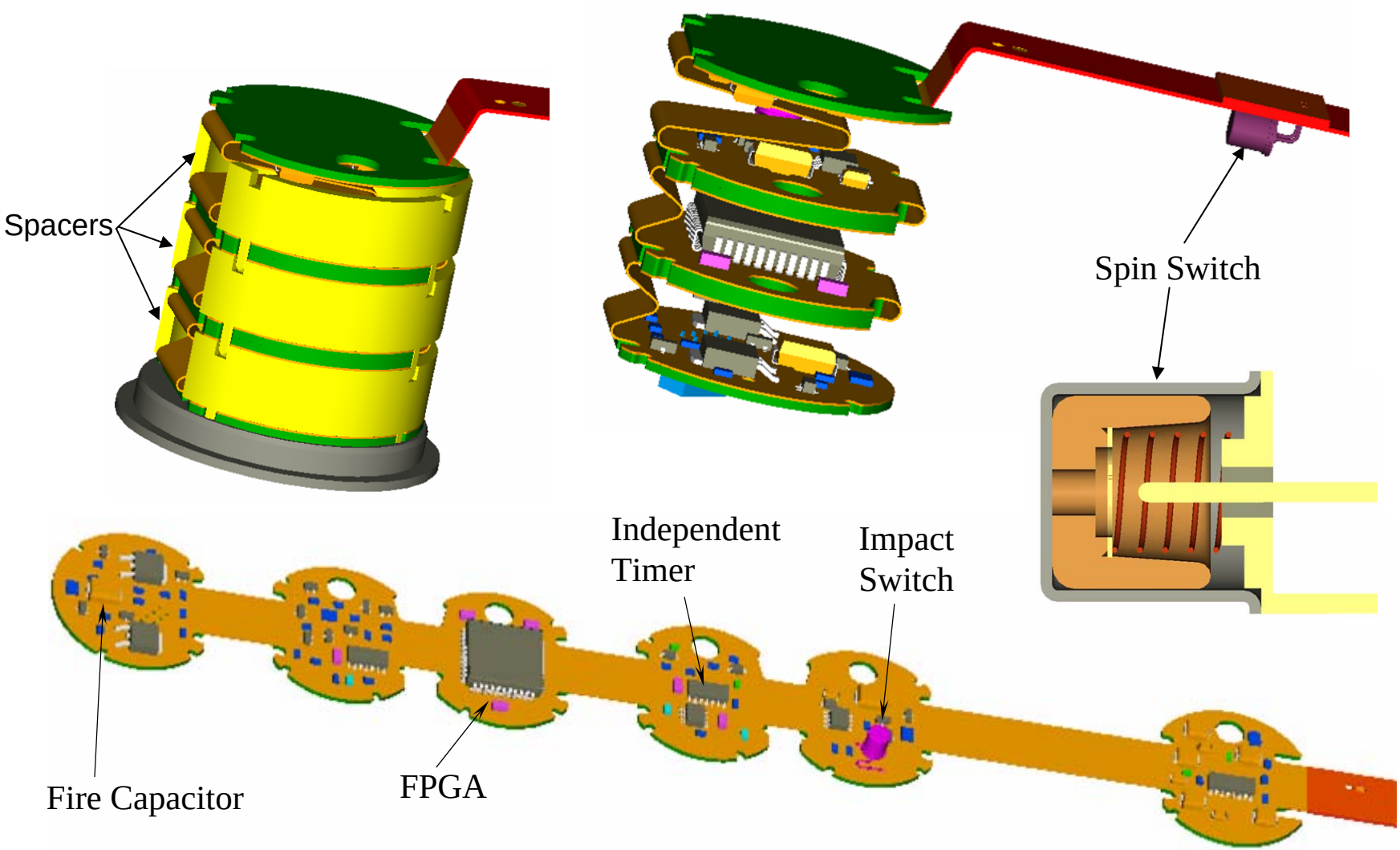
Electronic Flex Assembly



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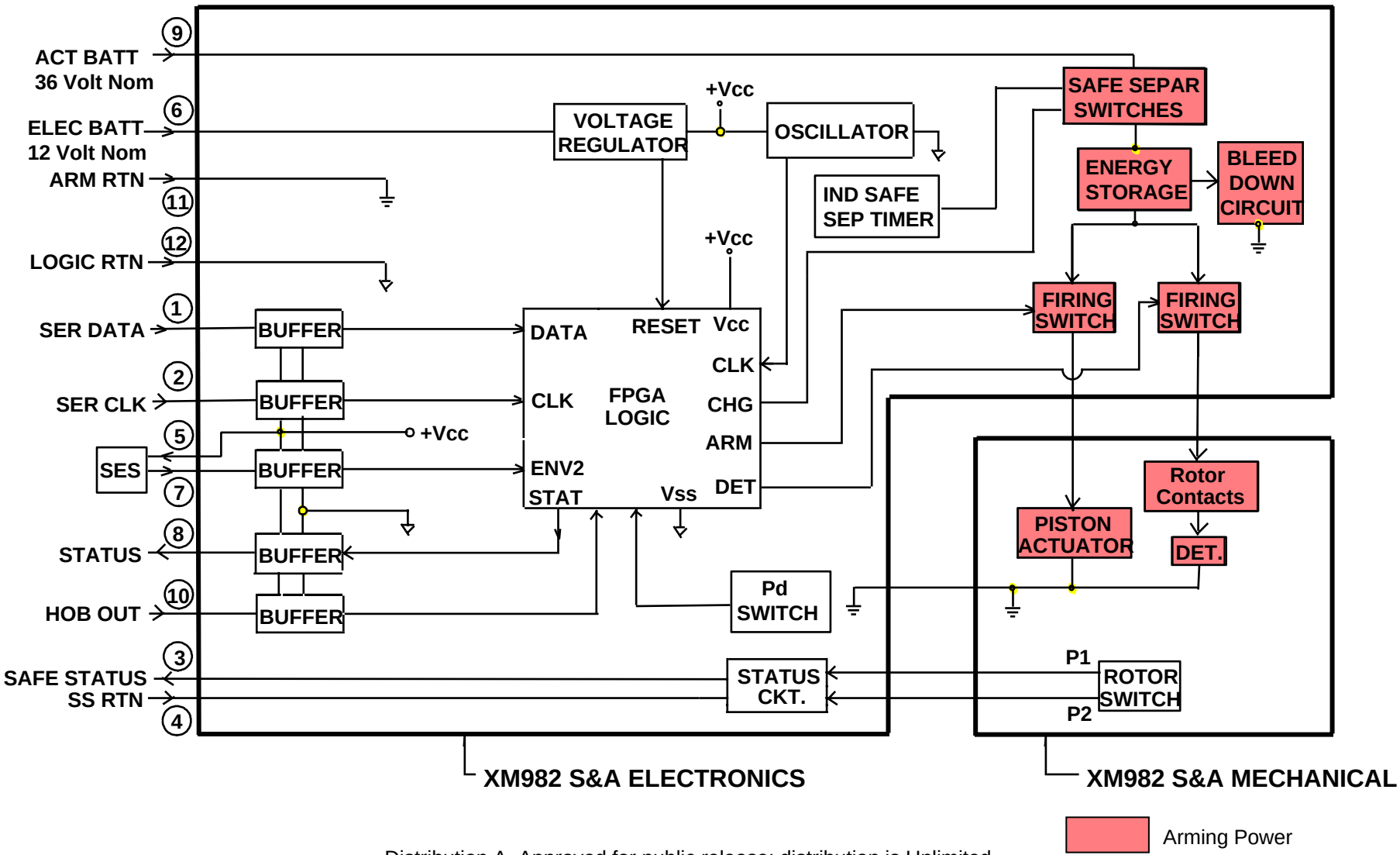
Electronics Functional Block Diagram



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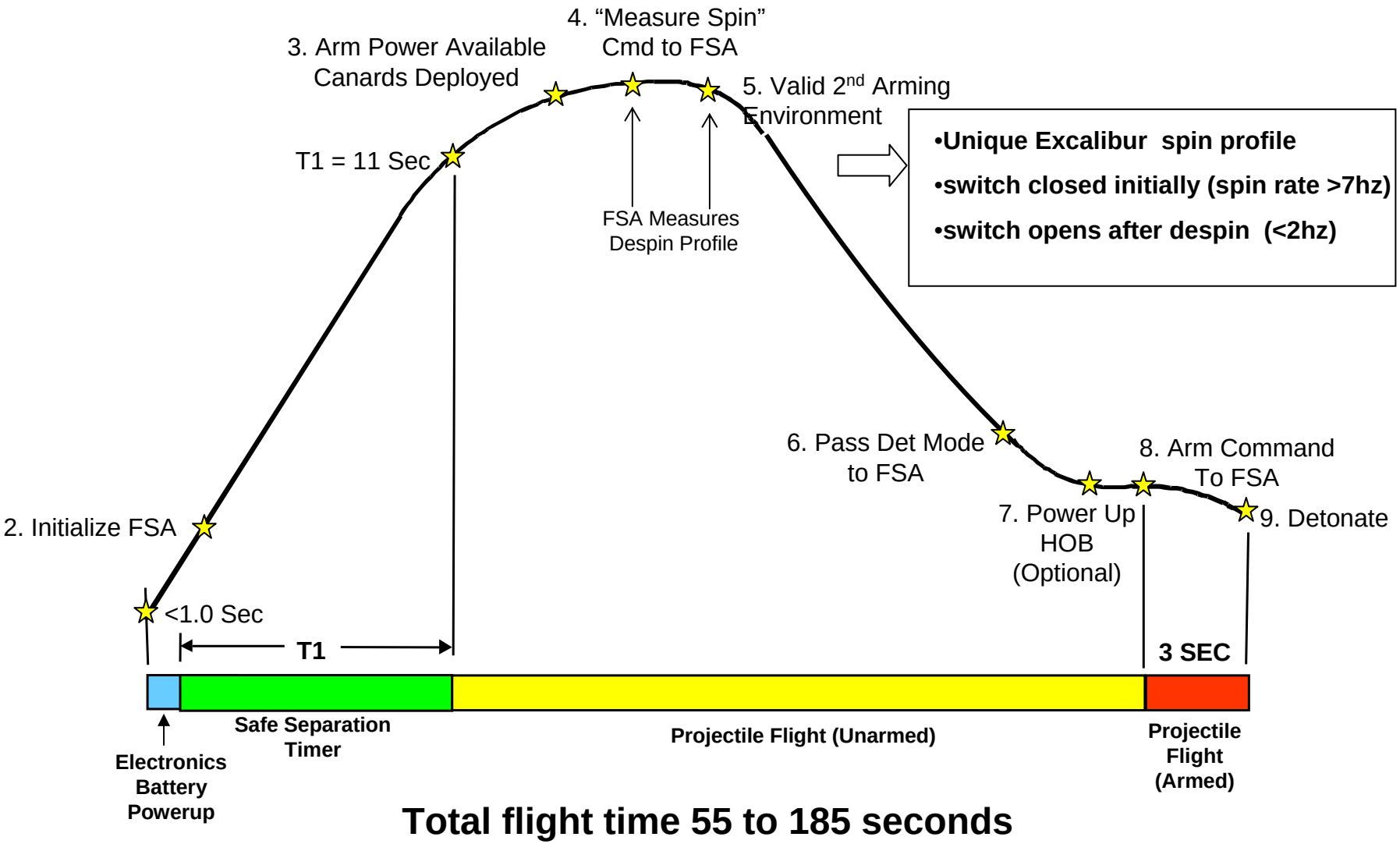
FSA /Flight Timeline



Total flight time 55 to 185 seconds

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Testing

- **FSA Component**
  - **Engineering tests**
  - **Design verification tests (DVT)**
    - **Mil Std-331 Seq environmental**
    - **Airgun, Railgun,Shock table, Centrifuge**
    - **Pre post Mechanical/electrical function checks**
    - **DVT 90 %complete**
  - **Qualification**
    - **Test matrix similar to DVT, Higher QTY**
- **Subsystem**
  - **Concrete penetration**
  - **Gunfirings Yuma, Bofors**
- **System**
  - **Safety test**
  - **Guided Gunfire**
  - **End to End Demo prior to early fielding**

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Significant tests and results

- **Gunfire - Setback force up to ~15KG's,**
  - **14 firings in 2004-05, 4 complete successes i.e.; FSA survived gunfire and impact, problems noted:**
    - **Setback mechanism not locked**
    - **1st lock interference issue**
    - **Spin switch**
- **Penetration – Steel reinforced concrete 4", 8" thick ~50KG+ axial force recorded**
  - **Sled tests conducted at Bofors Defense and GD OTS**
  - **Sled with rocket motors propelled on track up to 1000 ft /sec (max terminal velocity of round) into concrete wall**
  - **12 firings in 2004-05, FSA fully survived 2 firings, problems noted:**
    - **Housing deformation**
    - **Damaged electronics**
    - **Det contact open circuit**
    - **PA contact open circuit**

Sled test configuration

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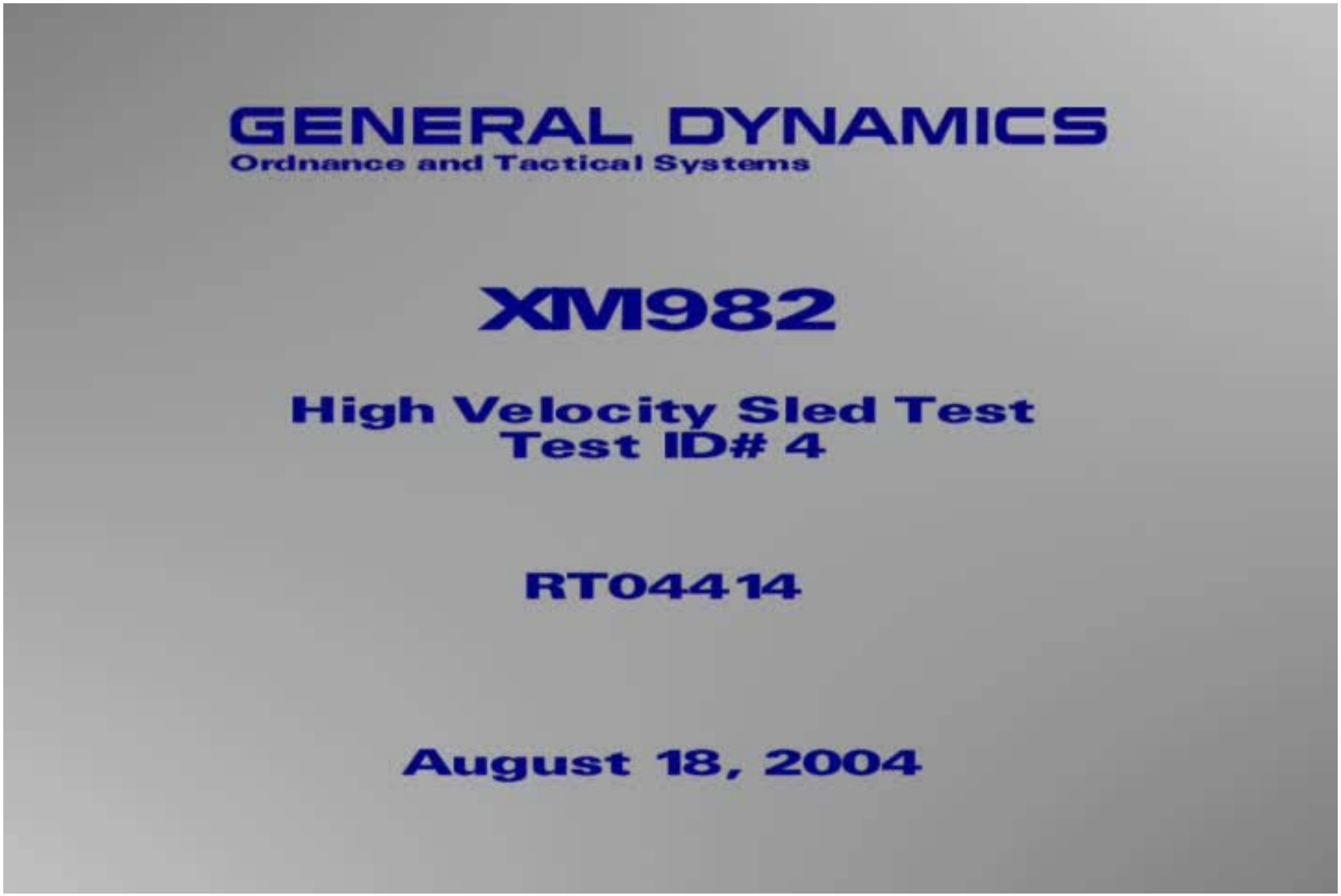
Penetration Test



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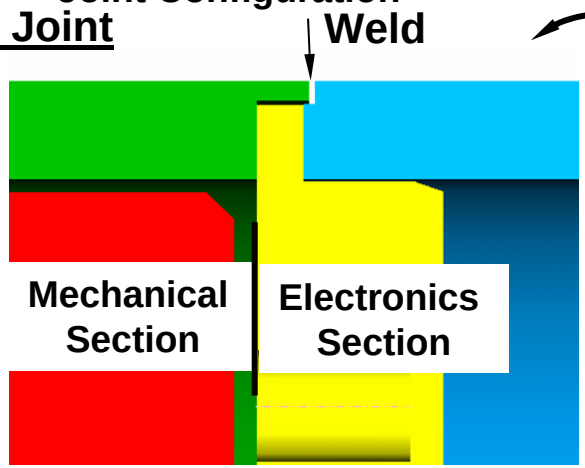
Housing & Electronics Section

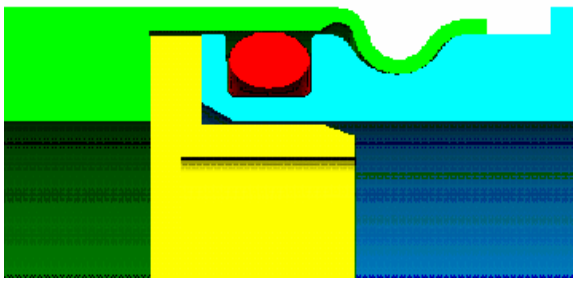
Housing Corrective Action

Mat'l - Steel (17-4 PH)
Orig- 2024 Al
Joint Configuration

Revised Joint



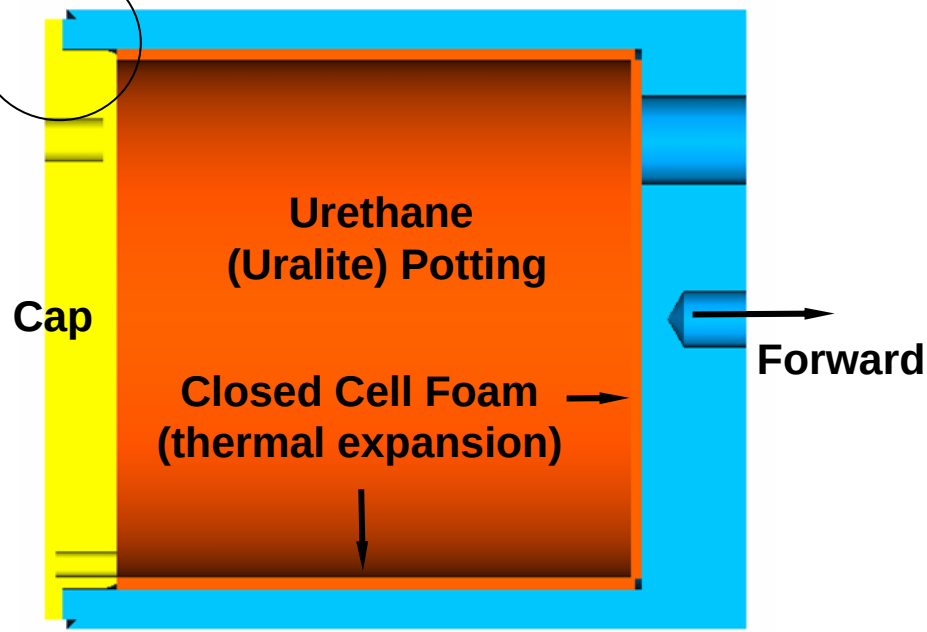
Original Joint



Electronics Fill Improvements

Urethane Potting
Foam for Thermal Expansion

•Latest rev- Polystyrene bead foam



Volume previously filled with glass beads

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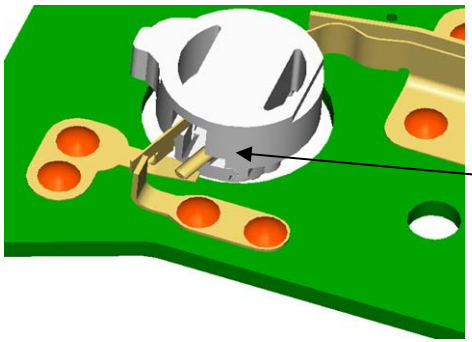
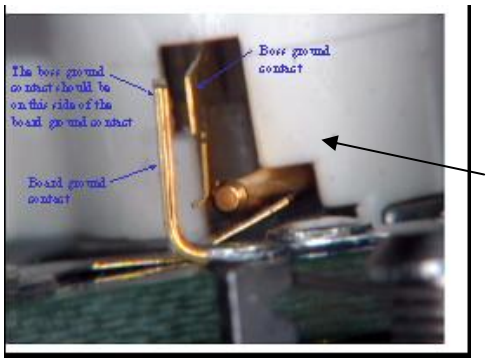
Contact improvements

Previous Design



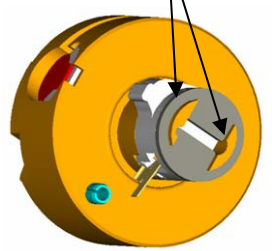
Rotor contacts properly positioned in armed condition



Contact pass by after penetration test

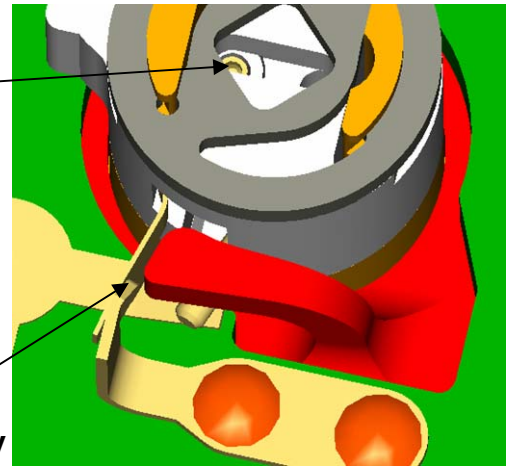
Damaged Contact Assy

Material Stake not adequate For 8” concrete environment

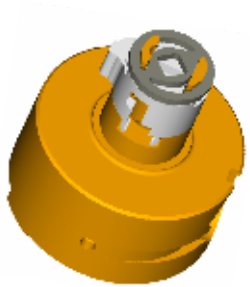


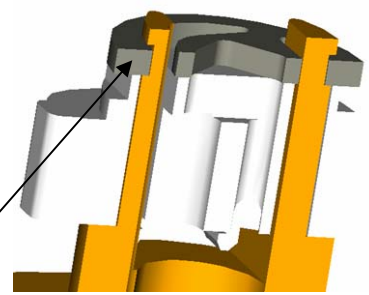
New Design

Slot for Continuity Check



Material “tab” and body backup added to prevent contact pass by





Section of retaining spacer rotates under “shelf” in rotor for positive engagement. Rotor material is then staked over to prevent spacer from rotating out of position

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Analyses

- Entire FSA analyzed prior to setback testing
  - Axial Setback: 15,500 g's +25%
  - Balloting g's: 5,000 g's +25%
  - Set Forward g's: 5,000 g's +25%
- Entire FSA analyzed prior to Penetration testing
  - Axial: 12,500 g's +25% (Actual ~50KG+)
  - Lateral g's: 6,800 g's +25%
- Setback mechanism issue
  - Set Forward and balloting loads caused previous version of mechanism to unwind due to ineffective detent (spring mass) design
  - Structural Analysis Engineering Corporation(SAEC) Cincinnati, Ohio contracted by KDI
    - Dynamic simulation of setback mechanism
    - Design and analysis of new leaf spring detent design.
    - Ansys/LS Dyna software was used
    - Performed 34 dynamic analyses including min/max cases with margin
    - Model predicted correct function of mechanism in each case
    - New leaf spring design functioned properly in subsequent gunfirings

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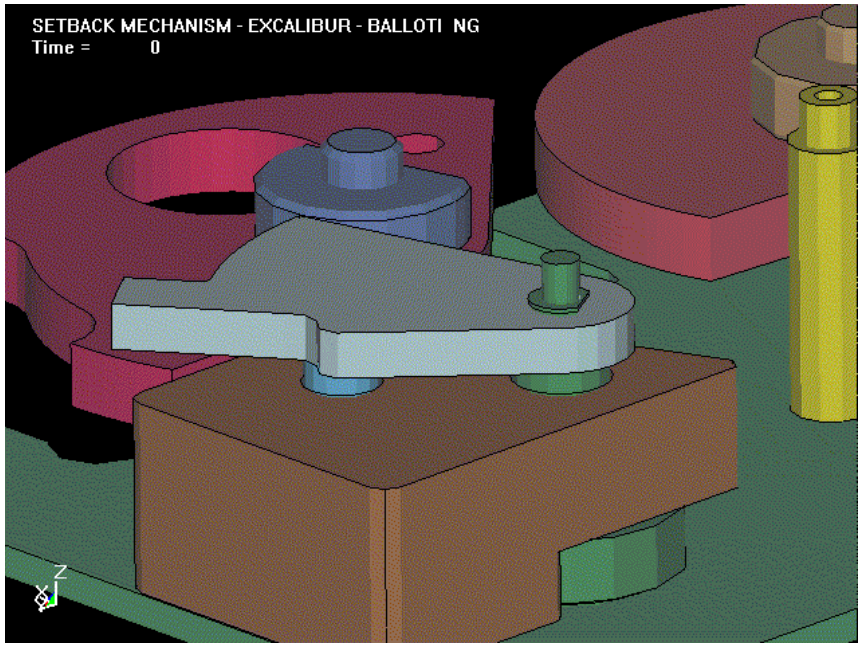
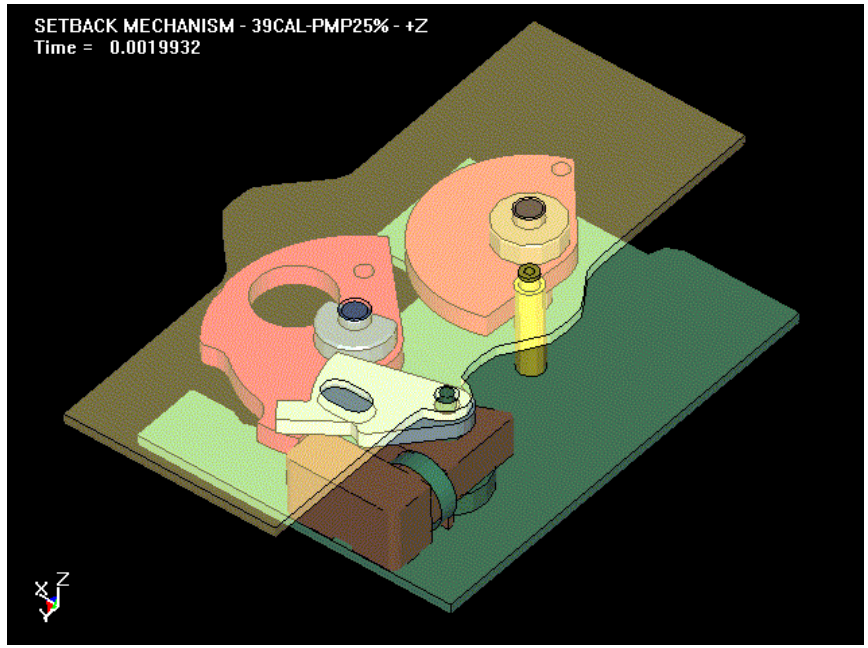
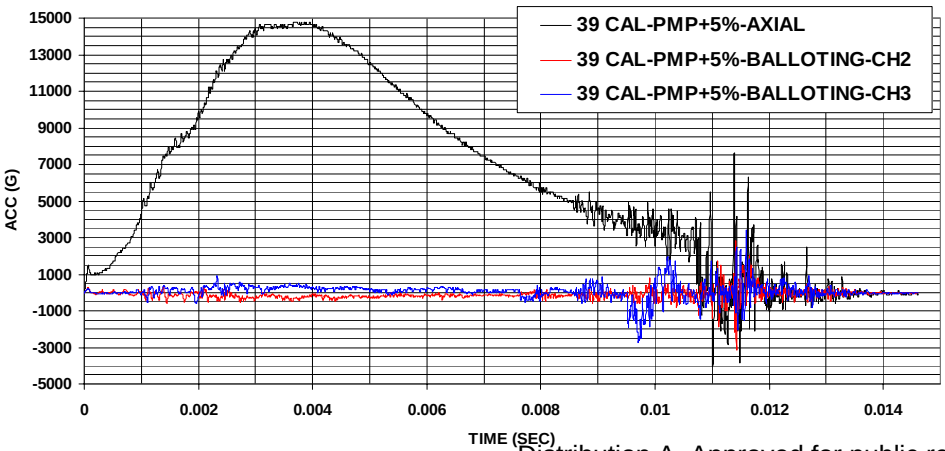
Setback mechanism

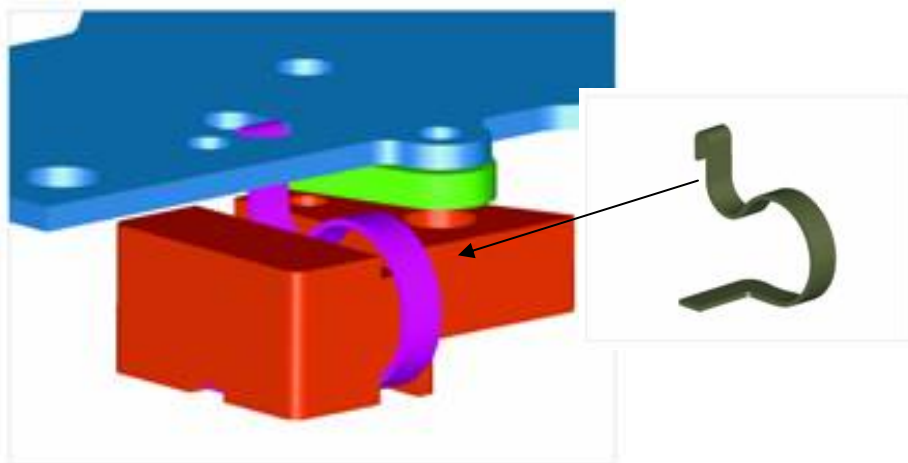
Original Design



New Design







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Summary

- **Significant progress made through Iterative design process**
- **Fuze safety and function modes verified by component and subsystem testing**
- **Setback and Penetration Environments**
  - **Design improvements identified/incorporated for survivability**
- **Fuze hardware maturing**
  - **Field test database increasing**

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