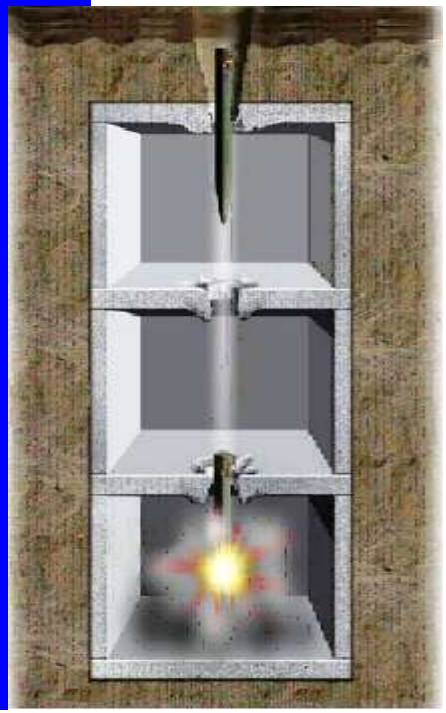
Void Sensing Fuze (VSF) Product Improvement Program (PIP) Transition of German Technology to Meet American Warfighter Needs

55th Annual NDIA Fuze Conference
24-26 May 2011



Co-presenters:
Dr. Helmut Muthig, TDW
Dale Spencer, Kaman Precision Products

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Foreword

- **This joint presentation by the Defense Threat Reduction Agency (DTRA), Kaman Precision Products, and MBDA/TDW highlights significant respective management and technology success in integrating across countries, companies and cultures for a DoD Product Improvement Program (PIP). The VSF PIP of the TDW Programmable Intelligent Multi-Purpose Fuze (PIMPF) into a US produced three inch fuzewell is an impressive story involving the cooperation of USAF, Navy, and DTRA. This effort puts to rest many concerns and reservations often held for programs requiring international cooperation.**

- **This presentation is dedicated to the memory of the late *Lt. Col. Herbert J. Smith III* who was a driving force in the inception of this program and who believed so strongly in the benefit to the American Warfighter that this technology and cooperation offers.**

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Agenda

- An overview of the DTRA Void Sensing Fuze Product Improvement Program
- Overview of the functionality of the Fuze
- VSF Cannon Testing at Meppen, Germany
- VSF Cannon Testing with USAF
- VSF Sled Testing with Navy
- Environmental Validation Testing Efforts
- Transition of VSF under a JCTD to US Weapons

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Historical Background

- **OSD Comparative Test Office and Defense Threat Reduction Agency (DTRA) sponsored Foreign Comparative Test (FCT) Program to evaluate the German's Programmable Intelligent Multi Purpose Fuze (PIMPF)**
  - PIMPF is a qualified fuze, currently in service in the Taurus KEPD 350 and has been selected for the Norwegian Naval Strike Missile
  - FCT program evaluated the ability of the PIMPF to penetrate hard, deeply buried targets, sense and count layers and voids as it penetrates, and then detonate in a specific void as programmed
- **Recommendation accepted to conduct a Void Sensing Fuze (VSF) Product Improvement Program (PIP) to repackage current PIMPF into a form factor compatible with US Weapon Fuzewells**

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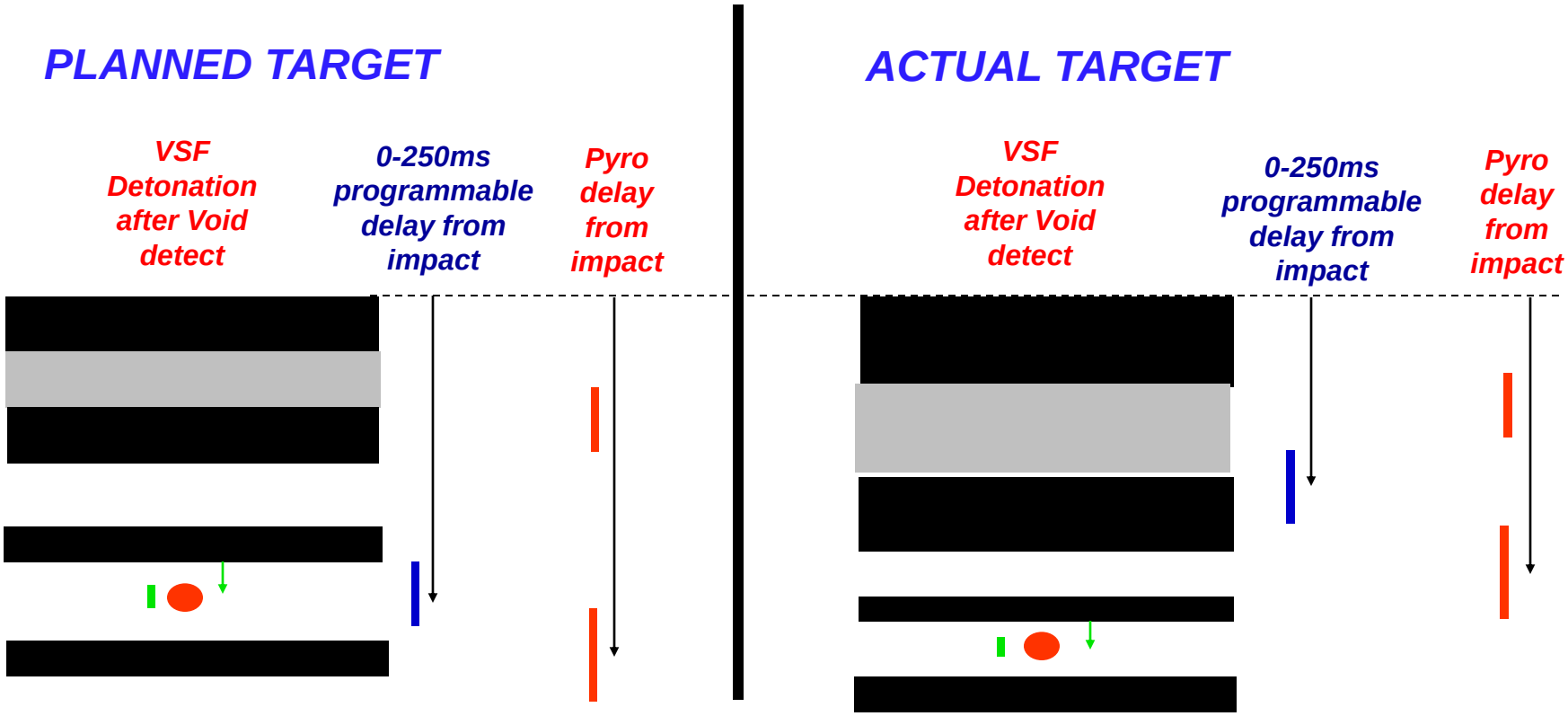
Benefits of Smart Fuzing

A Void Sensing Fuze Finds & Fires in Programmed Void



Void Sensing Fuze Provides Intelligence to Fire at Precision Location to Maximize Weapon Effectiveness

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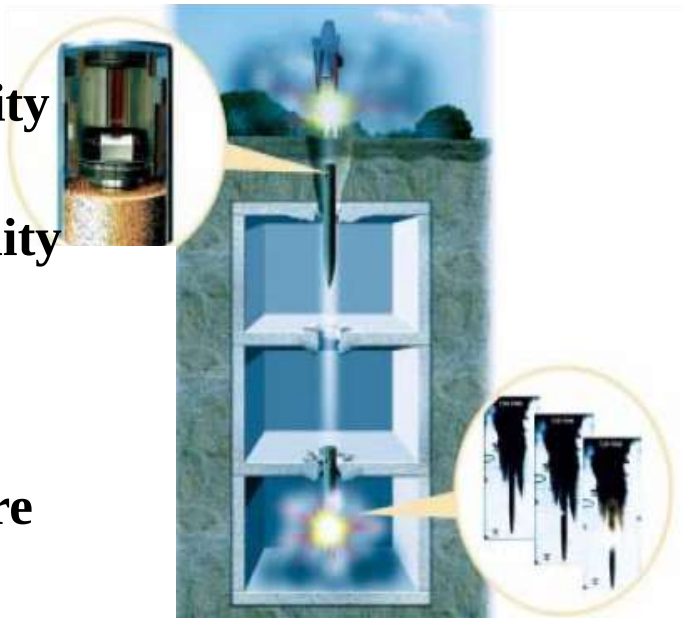
Void Sensing Fuze Objectives

Repackage the Programmable Intelligent Multi-Purpose Fuze (PIMPF) into a form factor compatible with US weapon fuzewells

- **Conduct trade studies to investigate compatibility with US weapon systems**
- **Demonstrate original void/layer sensing capability**
- **Conduct limited environmental/qualification testing**
- **Conduct USG Cannon/Sled testing to confirm functionality and serve as a risk reduction before USG integration**
- **Provide residual VSF for JMEWS development and make available for other transitional US partners**



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VSF Program Requirements

- VSF must meet NATO Standard Agreement 4187 and MIL- STD-1316E
- VSF must be sized to enable incorporation into standard US weapon fuzewell
- VSF must function within the operating environments of the host weapon system
- VSF must sense/count layers and voids as it penetrates a hard target and detonate at a planned point within the target
- VSF must be field-level and cockpit programmable

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VSF PIP Phases

- ***Phase 1 - VSF Modification and Demonstration ~ Completed***
  - **Trade Studies (capacitors vs batteries, connectors, modifications for gravity bomb applications)**
  - **Initial repackaging design**
  - **Component level environmental / shock testing**
  - **Engineering Evaluation Unit (EEU) design**
  - **Contractor led cannon testing (TDW at Meppen, Germany)**
- ***Phase 2 – US Pilot Assembly and Verification Testing ~ Working***
  - **Pilot production of multiple fuzes - *Completed***
  - **Production acceptance testing - *Completed***
  - **Environmental testing - *Pending***
  - **USG Production Verification Testing - *Completed***
    - **Cannon Testing with USAF at Eglin AFB – Risk Reduction to Sled Testing**
    - **Sled Testing with US Navy at China Lake**

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VSF PIP Participants

- *DTRA*
- *TDW / MBDA Missile Systems (Germany)*
- *KAMAN Precision Products*
- *AFRL ~ Eglin AFB*
- *NAVAIR ~ China Lake (SNORT)*
- *PMA-280 Joint Multi-Effects Warhead System*

U.S. AIR FORCE

NAVAIR

SUPERSONIC NAVAL ORDNANCE RESEARCH TRACKS
SNORT
NAVAL AIR WARFARE CENTER WEAPONS DIVISION
CHINA LAKE, CALIFORNIA

JOINT MULTI-EFFECTS WARHEAD SYSTEM JCTD
ANY TARGET ANY TIME ANYWHERE

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Roadmap to Success

VSF Program Milestones

- **DTRA funds FCT of PIMPF**
- **NNMSB Safety Review of PIMPF**
- **FCT Test of PIMPF**
- **DTRA awards Contract for VSF Product Improvement Program (PIP)**
- **VSF PIP SRR**
- **VSF PIP Preliminary Design Review (PDR)**
- **FISTRP Tech Assist Safety Review**
- **VSF Critical Design Review (CDR)**
- **VSF / TDW Validation Cannon Tests ~ Germany**
- **VSF Risk Reduction Cannon Tests ~ Eglin**
- **VSF Validation Sled Testing ~ Navy SNORT**
- **VSF Final Environmental Testing ~ Pending**

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Technology to Detect Voids with Penetrating Weapons

Dr. Helmut Muthig,

Managing Director, TDW / MBDA

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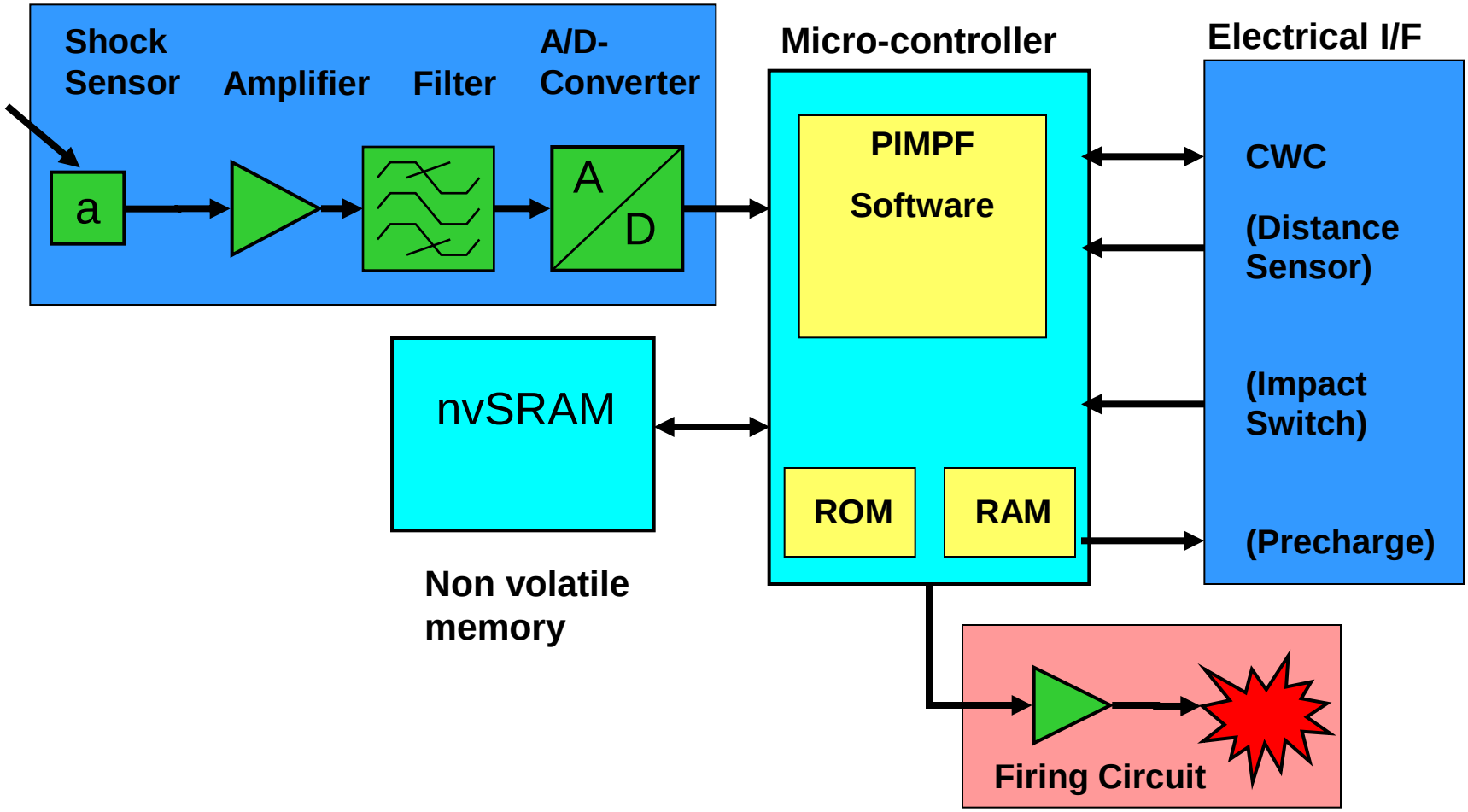
PIMPF TDD
Functional Block Diagram



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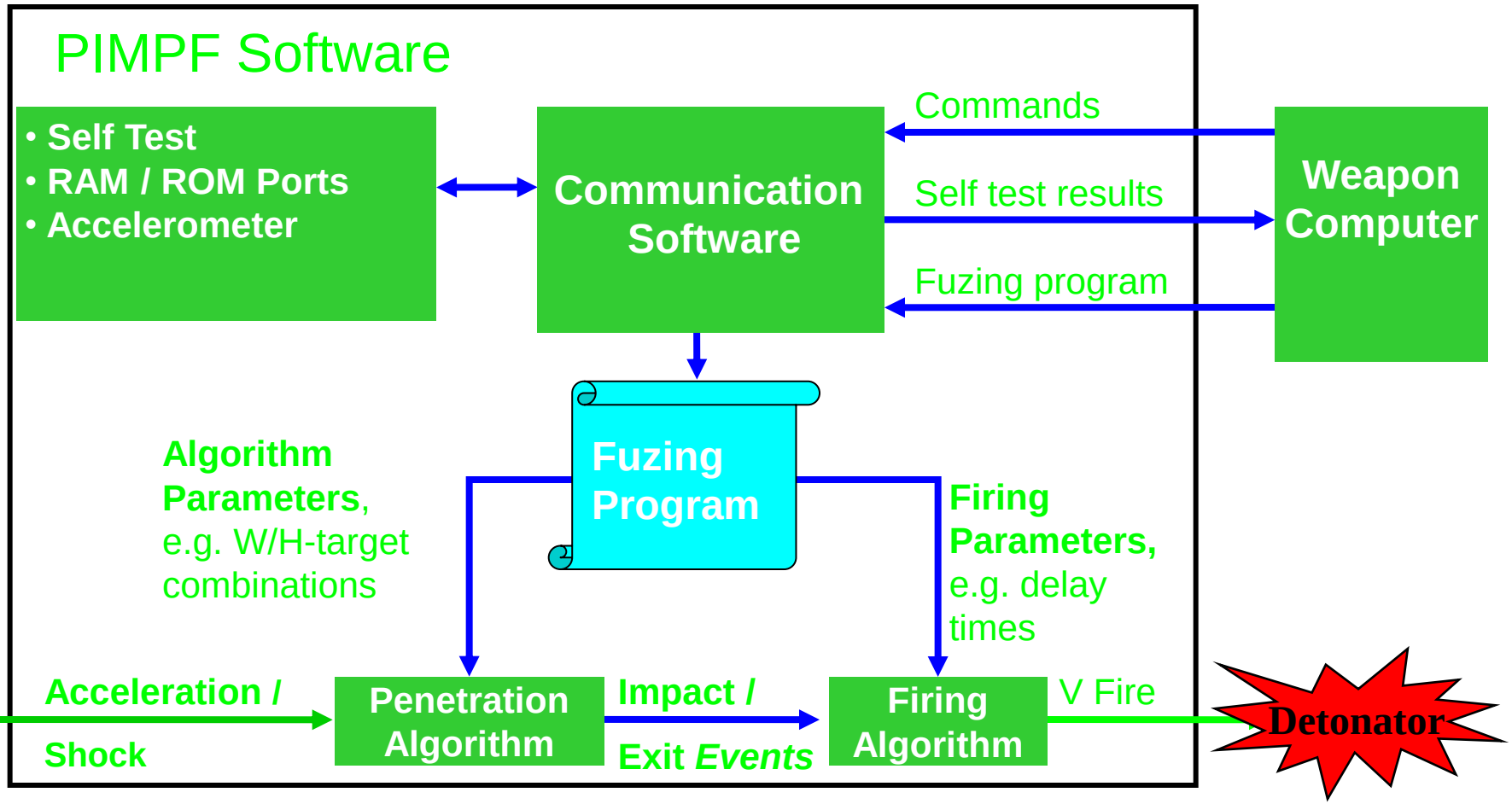
Functional Description ~ TDD



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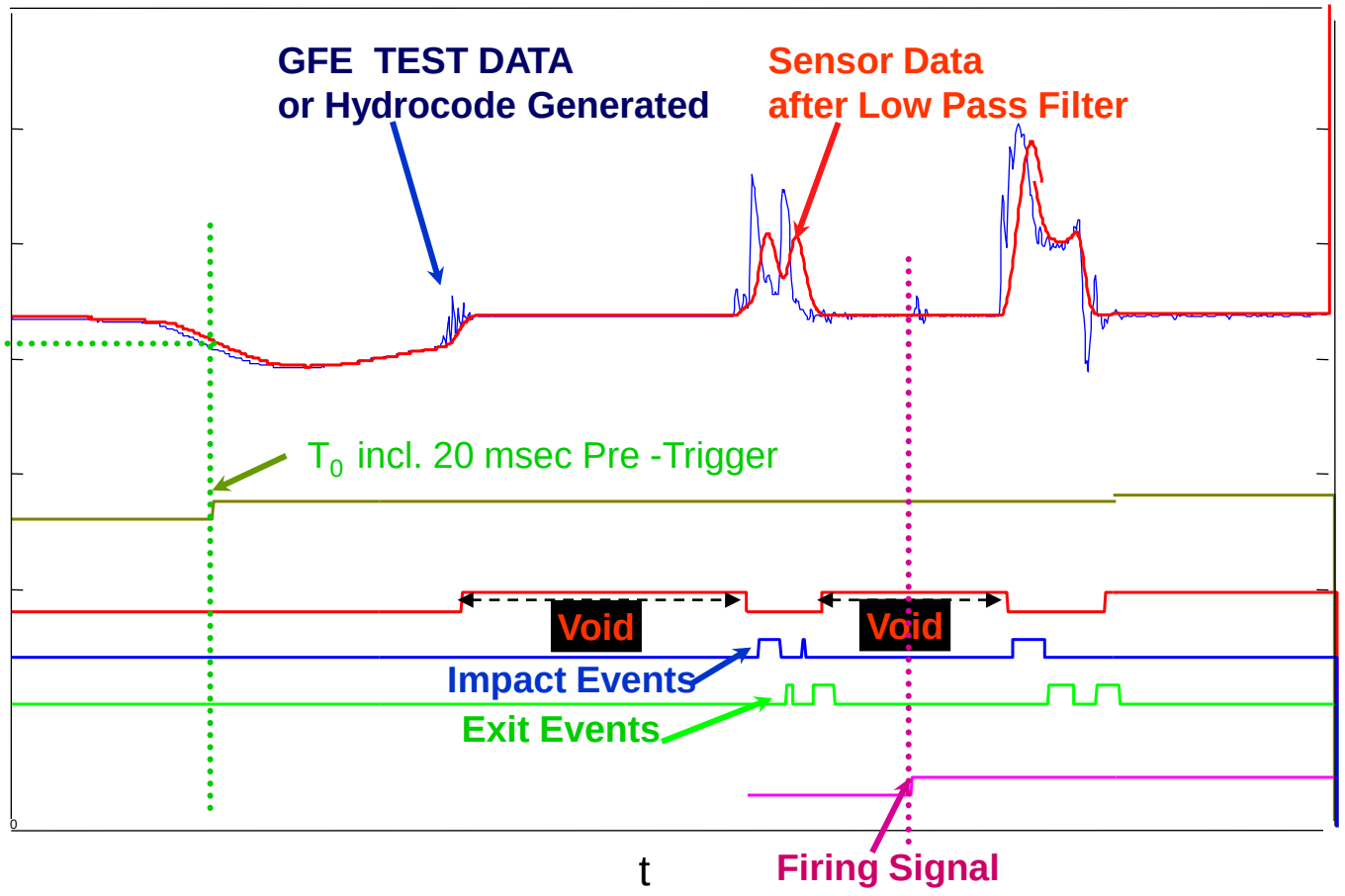
TDD Performance Prediction

VSM internal data logging capabilities



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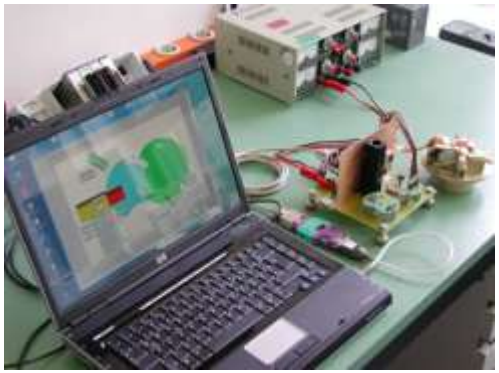
Contractor Testing Overview

- ✓ **Hardware in the loop testing**
- ✓ **Extended Temperature testing**
- ✓ **Booster Initiation Testing**
- ✓ **Detonator / Hand Safe Testing**
- ✓ **Acceleration (High Shock) testing**
- ✓ **Basic Environment /Robustness Testing**
- ✓ **Shock/Impact Testing at Meppen**
- ❑ **U.S. Environmental Testing**



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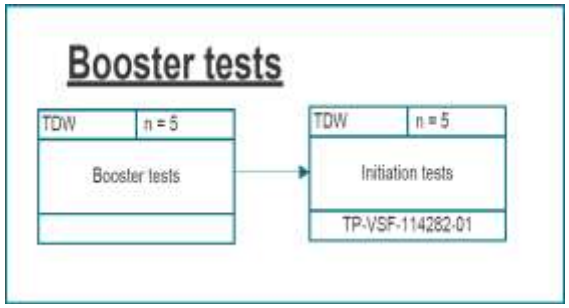
VSF Validation

- Detonator Safety Test
- Pyrotechnical I/F Test
- Basic Environmental and Robustness
- Test – Ulm Germany
- Explosive Compatibility Test
- CV / Penetrations Tests at WTD 91
- CV / Environmental Test

VSF Detonator Safety Report

VSF Pyrotechnical I/F Report



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VSF - TDW Validation Field Tests

Test #	Date	Target	Lessons Learned
1	6 June 2009	1 -- 2' 9.5" Reinforced concrete	Thread Design on Booster Cup to Fuze Housing Redesigned -- Threaded Booster Facilitates Testing
2	15 June 2009	2 – 15.5" Reinforced concrete plates	Rotor Flange angle relieved Booster Cup Teflon Damping Ring redesigned for greater robustness
3	28 Oct 2009	1 – 5'5"	Enhancements to flex interconnect cable and addition of flex retaining bracket
4	23 Feb 2010	2 – 15.5" Reinforced concrete	TDW Contractor Led Cannon Tests verified CIPPS: APP Functionality; Entry/Exit Detection @ critical impact velocities and angles

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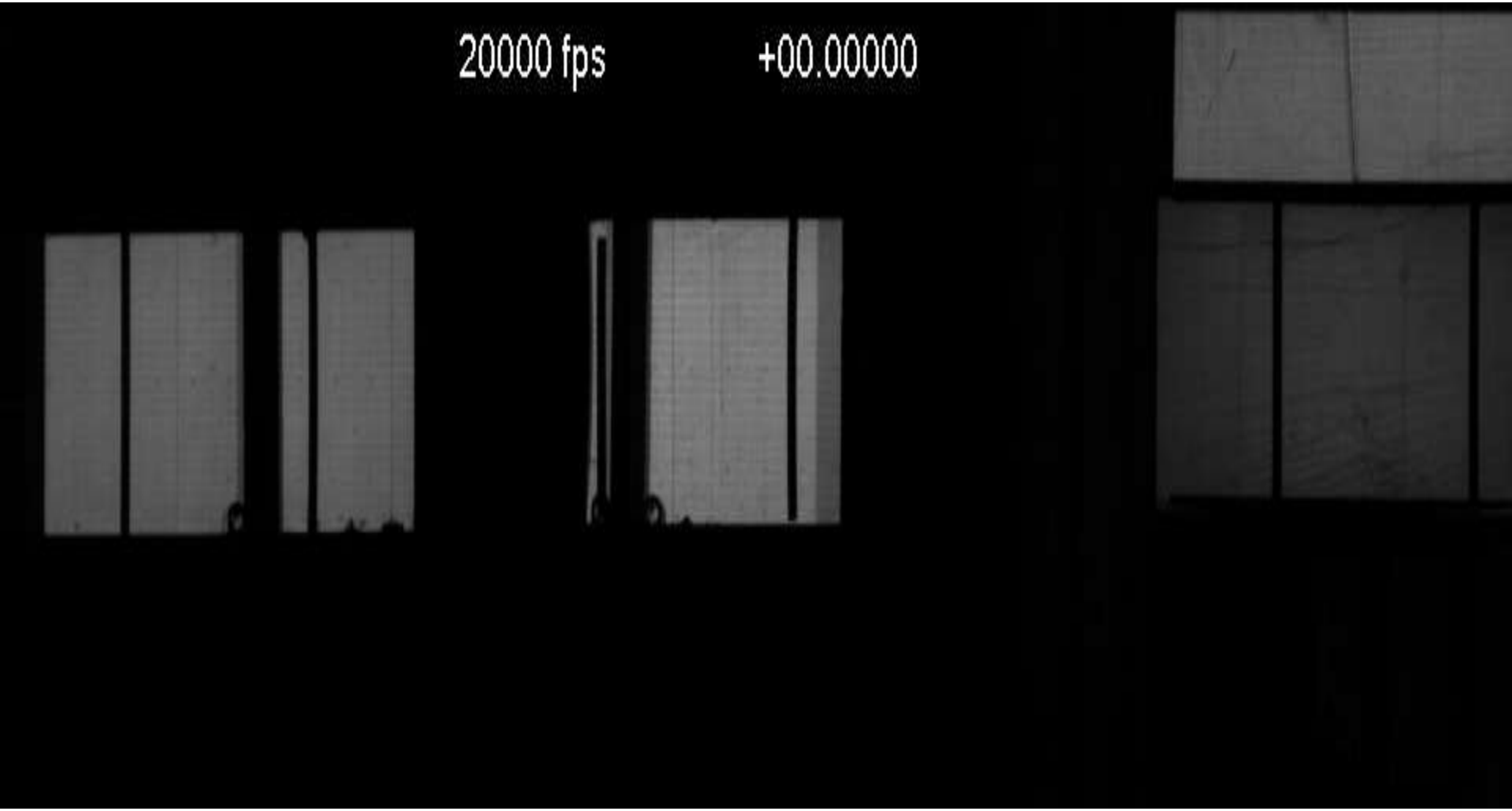
VSF Contractor Penetration Testing
Cannon Test ~ Double Concrete Plate



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VSF

VSF ~ USG Testing
Dale Spencer
Kaman Precision Products

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VSF ~ USG Cannon Risk Reduction Testing

- **Total of 4 Cannon Test Events**
- **Cannon Test #1 - Eglin Air Force Base**
  - **Objective:** Survivability and Functionality
    - Repeat of the TDW Contractor Validation Test conducted previously to confirm the integrity of the design high G load, and verify TDD ability to detect void layer
  - **Confirmation:** No Test
    - Pusher Plate Failed due to material failure
    - Fuze Burned, TDD Recorded and Functioned Post Test

"The fact that the TDD survived the extreme gun gas pressure and extremely high gas temperature is remarkable."

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VSF ~ USG Cannon Test #2

- **Cannon Test #2 - Eglin Air Force Base**
  - **Objective:** Survivability and Functionality
    - Repeat of the TDW Contractor Validation Test conducted to confirm void/layer detection, survivability, and functionality of the VSF at distance from gun barrel to front of first target layer
    - Verify VSF integrity and exposure to **High Lateral G loading**
  - **Confirmation:** VSF Complete Success Despite Warhead Breakup
    - Fuzewell separates from the penetrator and travelled about 30 ft from the final concrete target slab
    - Fuzewell sustained severe deformation with fuze retaining ring lock-up
    - TDD functioned as programmed despite violent separation from penetrator that was exposed to severe tail slap
    - Void Sensing Fuze remains intact and undamaged in damaged Fuzewell
    - Final exit & fire signal generated successfully as programmed despite violent separation from penetrator

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VSF ~ USG Cannon Test 3 & 4

- **Cannon Test 3 & 4 ~ Eglin Air Force Base**
  - **Objective:** Survivability and Functionality
    - Test #3 is to confirm multiple void/layer detection, survivability, and functionality of the VSF through double concrete plate
    - Test #4 is to confirm multiple void/layer detection, survivability, and functionality of the VSF through multiple concrete plate and compact soil
  - **Confirmation:** Complete Success both tests
    - The TDD functioned as programmed; traces show entry and exit from each concrete target and difference in deceleration levels between concrete and soil configuration
    - The final exit & fire signals were generated as planned
    - No damage to VSF Fuzewell or VSF
    - Inert VSF with Kaman HIDR in Booster Cup ~ reused multiple times

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VSF ~ USG Sled Testing

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VSF ~ USG Sled Testing

- **Total of 3 USG Sled Test Executed Successfully ~ China Lake**
- **Objective: Verify Survivability, Functionality, and ability for VSF to command fire signal at appropriate Pre-Programmed Void Layer Tests**
- **VSF Sled Test Parameters included:**
  - Void Sensing Fuze's conf/w Live Detonator/Inert Lead to enhance data collect & verify 'Fire' Command ~ (HIDR)
  - Pre/Post Test modeling for Risk Reduction, Comparison, and Model Update
  - Penetrator configuration designed to mitigate lessons-learned from PIMPF (FCT)
  - Penetrator engineering designs minimal for VSF

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VSF ~ USG Sled Testing Snapshot

Primary Objective: Functionality & Survivability

- **VSF Sled Test #1**
  - Repeat of the PIMPF FCT test to confirm no capabilities were lost between PIMPF and VSF during the PIP program
  - Verify VSF integrity and exposure to high lateral G loading
- **VSF Sled Test #2**
  - Demonstrate VSF ability to detect the void space behind known target and issue a fire signal after exiting that target
- **VSF Sled Test #3**
  - Demonstrate the ability of the fire signal to initiate the detonator ~ HIDR
  - Determine the ability of the VSF to detect various target thickness and issue appropriate entrance and exit signals
- **Confirmation on all 3 USG Sled Tests: Complete Success**
  - The TDD functioned as programmed in all test scenarios
  - The final exit & fire signals were generated as planned
  - The TDD traces clearly showed the entry and exit from each target set
  - HIDR used during Test #3 showing useful x,y,z axial data

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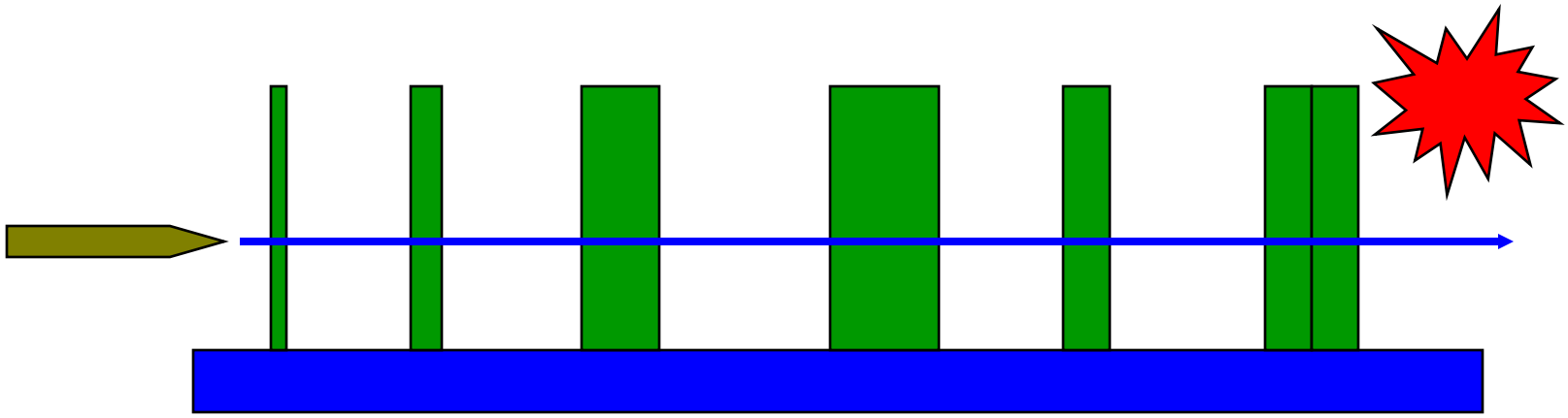
VSF ~ USG Sled Testing Snapshot

Primary Objective: Functionality & Survivability

Example of VSF Sled Testing
Multiple Target Penetration



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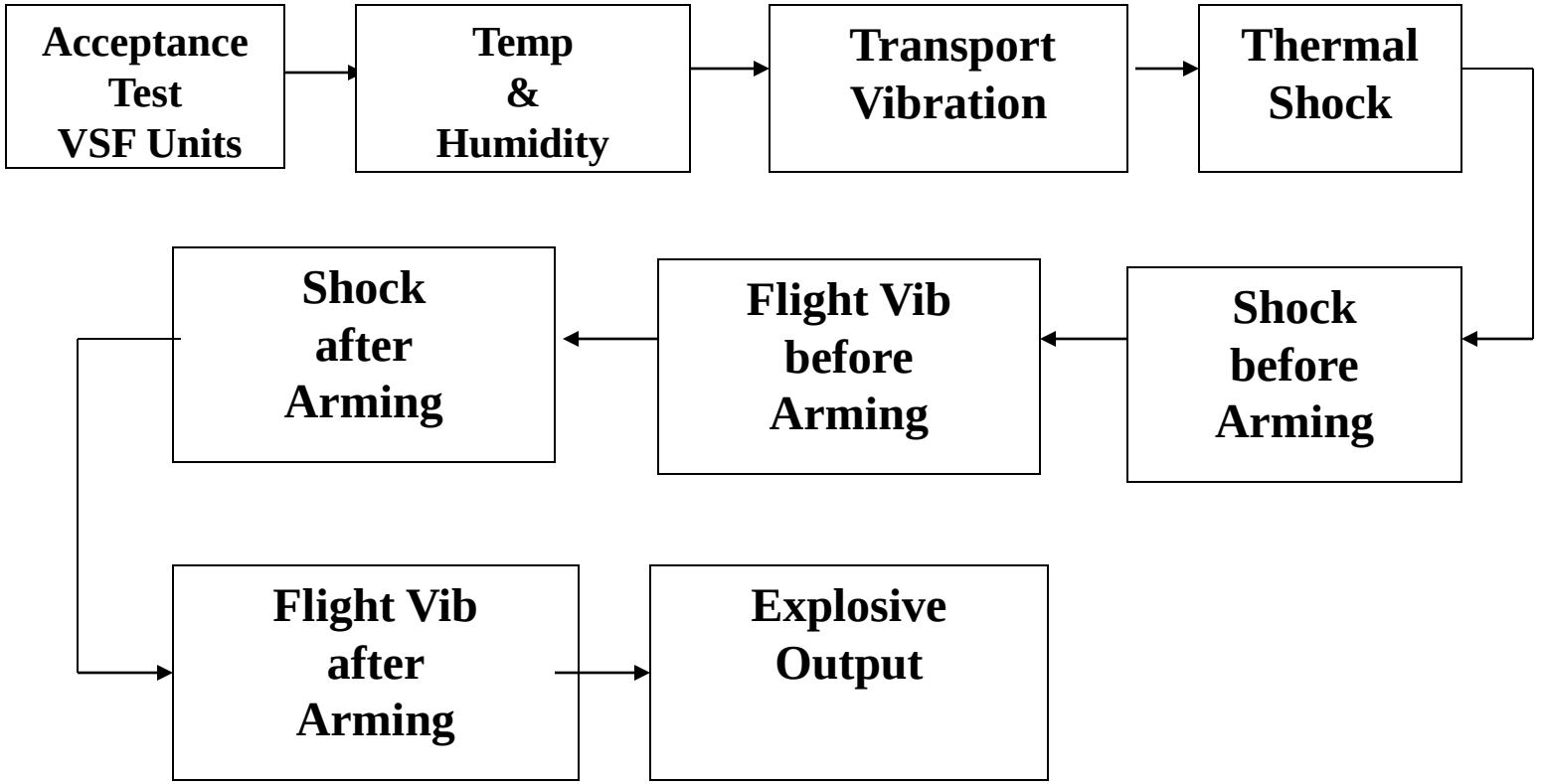
Environmental Verification Testing

- **Objective: verify the capability of the VSF to perform within the required specifications prior to, during and following exposures to various environments – Pending**



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VSF ~ Transforming Future Warfighter Capability & Integration

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