European LEEFI Based Fireset and ESAD

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JUNGHANS Defence – Max Perrin, Chief Technical Officer
Outline

- New Fuze/SAD Requirements
- Electronic S&A Devices / EFI – Benefits and Background
- LEEFI Based ESAD – Benefits and New Applications
- LEEFI Based Fireset and ESAD – Development Objectives
- Current Programs and Technical/Product Achievements
- Conclusions
Complete range of fuzes for all types of munitions

Key competences in Fuzing technologies, Micro-technologies and Ammunition electronics
New Fuze / S&A Device Requirements
New Trends

SAFETY
- IM (Insensitive Munitions)
- STANAG 4187 (2nd Safety Feature)
- STANAG 4368 – Motor ISD
- Self-Destruct Feature
- Self-sterilization / self-neutralization
- Overflight Safety
- Mission Abort
- Back-to-Safe
- Fail-Safe Design

TERMINAL EFFECT
- Tailorable / Scalable Effects
- Tunable / Aimable Warhead
- Collateral Damage Reduction
- Hard Target Fuzing

OPERATIONAL FLEXIBILITY
- Multi-mode / Multi-missions
- Mode Selection
- Before Flight / In-Flight

SAFETY TERMINAL EFFECT

Munition - Weapon System

Fuze
Safety & Arming & Firing Device

Modularity
Miniaturization
Shock hardening
**New Requirements – New Functions**

*Need for a Safety, Arming and Firing Function with*
- New Functionalities
- More Flexibility
- More Control

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**Modularity**
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**Miniaturization**
- Mode Selection
- Before Flight / In-Flight
- Multi-mode / Multi-missions

**Shock Hardening**

*MP - May 2016*
Electronically Controlled S&A Devices

- New functionalities
- Better control of arming / firing

Electromechanical SAD (interrupted train)

Solutions

Electronic SAD (in-line)

- Needs Electronic Control of the Safety & Arming Function

 EFI : Exploding Foil Initiator (Slapper Detonator)
Key components of the fireset

- EFI
- HV capacitor
- HV switch
- Voltage converter
Electronic Safety and Arming Technology - Main Benefits

- High level of insensitivity (IM) with secondary explosives
- Resistance to electromagnetic and electrostatic disturbances
- Able to withstand very high mechanical stresses (hard target penetration)
- Flexible: electronic safety management and safety event processing
- Makes testing operation easier during the whole life-cycle
- Come back to initial safe status in case of system failure (collateral damages and UXO risk reduction)
- Enables "smart warhead" design (multipoint initiation, precise ignition timing)
- STANAG 4187 ed.4 safety design compliant
Company background in ESAD / EFI area

30 years experience in ESAD and slapper detonators

VT1 ESAD
ASTER ESAD
AS30LS ESAD
ASTER (2) ESAD
FBM21 Bomb Fuze
Heavyweight Torpedo Fuze
FBM21 Upgrade (LEEFI)

1990
2000
2010
2015

Strip line EFI
Plug-in EFI
LEEFI study start (PV)
SCB LEEFI research (MCM ITP FR-UK)

1990
2000
2010
2015

30 years experience in ESAD and slapper detonators

French MoD contract awards for LEEFI development
LEEFI-based SAD

Fireset Control Electronics (Safety Management) Interface Electronics

Environment/Safety Event Sensors

High Voltage and Firing Electronics

EFI LEEFI (1000 to 1500V)

Mechanical Structure

ESAD

1500V capacitor instead of 3000V capacitor

Replacement of Triggered spark gap switch by new HV switch solution: Solid-state switch or Hybrid solid-state / spark gap switch
Main benefits provided by LEEFI technology (Low Energy Exploding Foil Initiator)

- Lower design constraints
  - Circuit layout is made easier due to reduced voltage
  - Increased margin

- Smaller size
  - Smaller circuit design and smaller high-voltage components
  - Adaptability to various applications sizes and form factors
  - Higher resistance to high shock

- Lower cost
  - Lower voltage enables the use of standard components instead of application specific HV components

Enable the use of ESAD solutions in a broad range of applications, for both munitions and missiles
Main/New Applications for LEEFI Based ESAD

- **Rocket Motor Ignition**
  - STANAG 4368 compliance
  - Possibility of multi-pulse ignition (dual stage motor)
  - Possible use of TBI (through bulkhead initiation device) or direct ignition of propellant
  - Adaptation to various form factors

- **Smart warhead initiation**
  - Multi-point initiation for selectable and tailorable effects
    - Smaller size firesets
    - Precise control of timing
  - Possible combination of both Warhead and Rocket Motor safety/firing control device

- **Guided munitions and small missiles warhead SAD**
  - Fuzing/SAD functions distributed
  - Multi-point initiation
JUNGHANS Defence's LEEFI Based Fireset Development Main Objectives

- Rely on company background, proven through several EFI and ESAD products design and manufacturing
- Select key materials and components of the LEEFI and fireset from secured supply chains
- Optimize the LEEFI-based fireset design and manufacturing, as a whole (not only as single LEEFI component)
- Design LEEFI/Fireset capable of all expected applications from hard-target weapon to aerial-target weapon, for warheads and rocket motors
- Consider industrial constraints, either in the manufacturing process or from the supply chain
  - Keep required performances even with possible deviations from materials and components

Versatile LEEFI based fireset with robust design
Current programs (DGA programs)

- **French MoD (DGA) support to LEEFI based ESAD through two R&D contracts**
  - **1 - Development of LEEFI based ESAD**
    - Objective: obtain a qualified source for LEEFI and key components (including HV switch)
    - ESAD modular design (Missile integration flexibility)
    - Compatible with hard-target warhead weapon application
  - **2 - Design/validation of LEEFI based ESAD able of multipoint initiation (ignition) warhead**
    - Up to 6 initiation points

- **Objective: obtain mature technology enabling new ESAD/Fuze development**
  - LEEFI characterized according to STANAG 4560
  - Fireset and ESAD performances validated in relevant environment conditions (shock / acceleration, extreme temperatures)

**Significant support from French MoD (DGA) has enabled to achieve mature design of a LEEFI and LEEFI based Fireset**
LEEFI design: Validation of the main parameters
- Expected operating voltage achieved
- Bridge dimensions and thickness (copper bridge)
- Flyer material and deposition process
- Explosive material compound (HNS-IV + binder)
- Mechanical integration
- Bridge chip connection

Plug-in LEEFI component:
- Easy connection/disconnection on the fireset/ESAD
- Benefits for ESAD testing, compliance with increasing reliability demands

High shock resistance validation
- Tested on concrete slab firing shock > 10,000g

Optimization of the parameters, in consistency with the various components of the fireset
- STANAG 4560 characterization

LEEFI design is validated with the whole spectrum of specifications
Main Achievements
Fireset Main Components

- **High-Voltage Switch: Assessment of various options**
  - COTS solid-state components, including "one-shot" components: possible but main drawbacks and risks
    - Option rejected
  - Design of a new silicon switch (MOS technology) from European founder:
    - Good results obtained with industrial prototypes
  - Design of an alternative HV switch solution: spark gap + semi-conductors circuit
    - Validated with the whole spectrum of specification
    - Tested performances are compliant with operational as well as testability requirements

- **All high-voltage components, including HV converter, integrated in the independant fireset module**

Key components of the Fireset have been fully validated
Main Achievements
Fireset Module

- **Fireset module**
  - Designed in view of distributed multi-point initiation, in the frame of these projects
  - Link with ESAD Control Electronics is carried out by low-voltage connection
  - Tested under high-shock condition (hard target penetration)

- **Other fireset designs achievable, with different form factors, distributed or integrated within ESAD / ISD**

- **Design and validation of a LEEFI version specifically adapted for rocket motor ignition, directly igniting propellant**
  - Small size and cost-effective solution compared to the use of TBI component
- ESAD, carried out in the frame of the running programs, incorporate safety control electronics, mission management and interfaces electronics

- Two ESAD versions, based on similar basis, have been developed, and adapted to the specific requirements
  - 1- with 6 fireset modules (multipoint initiation warhead: 6 initiation points)
  - 2 - with 4 fireset modules (2 initiation point for warhead, 2 ignition pulse for rocket motor)

- Any other option with fireset integrated inside ESAD/ISD housing can be achieved
End 2015: French MoD awarded a contract to JUNGHANS for an upgrade of FBM21 aerial bomb fuze, to implement additional functionalities as well as the new LEEFI based fireset

- Implementation of LEEFI fireset and ESAD in munition fuzes, produced in large quantities, will ensure the continuity of such technology

- JUNGHANS product range extension: new missile or munitions warheads ESAD and rocket motors ISD (including multi-point initiation) based on LEEFI technology
- Low Energy EFI technology enables the use of Electronic S&A Device solutions in a wide range of applications, for both munitions and missiles

- JUNGHANS Defence has developed a robust LEEFI based Fireset in order to meet its customers' new requirements
  - to provide them with additional functionalities and more flexibility in new designs of missiles/munitions warheads or rocket motors
  - to guarantee their supply on this key technology
Thank you for your attention.

Max Perrin
Chief Technical Officer
max.perrin@junghans-defence.com