European LEEFI Based Fireset and ESAD

JUNGHANS Defence



59th NDIA Fuze Conference

"Fuzing Systems for Advanced Weapon Performance"

CHARLESTON, SC - May 3-5, 2016

JUNGHANS Defence – Max Perrin, Chief Technical Officer

A Diehl and Thales company

Outline

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- 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

JUNGHANS Defence – The Fuze Company

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

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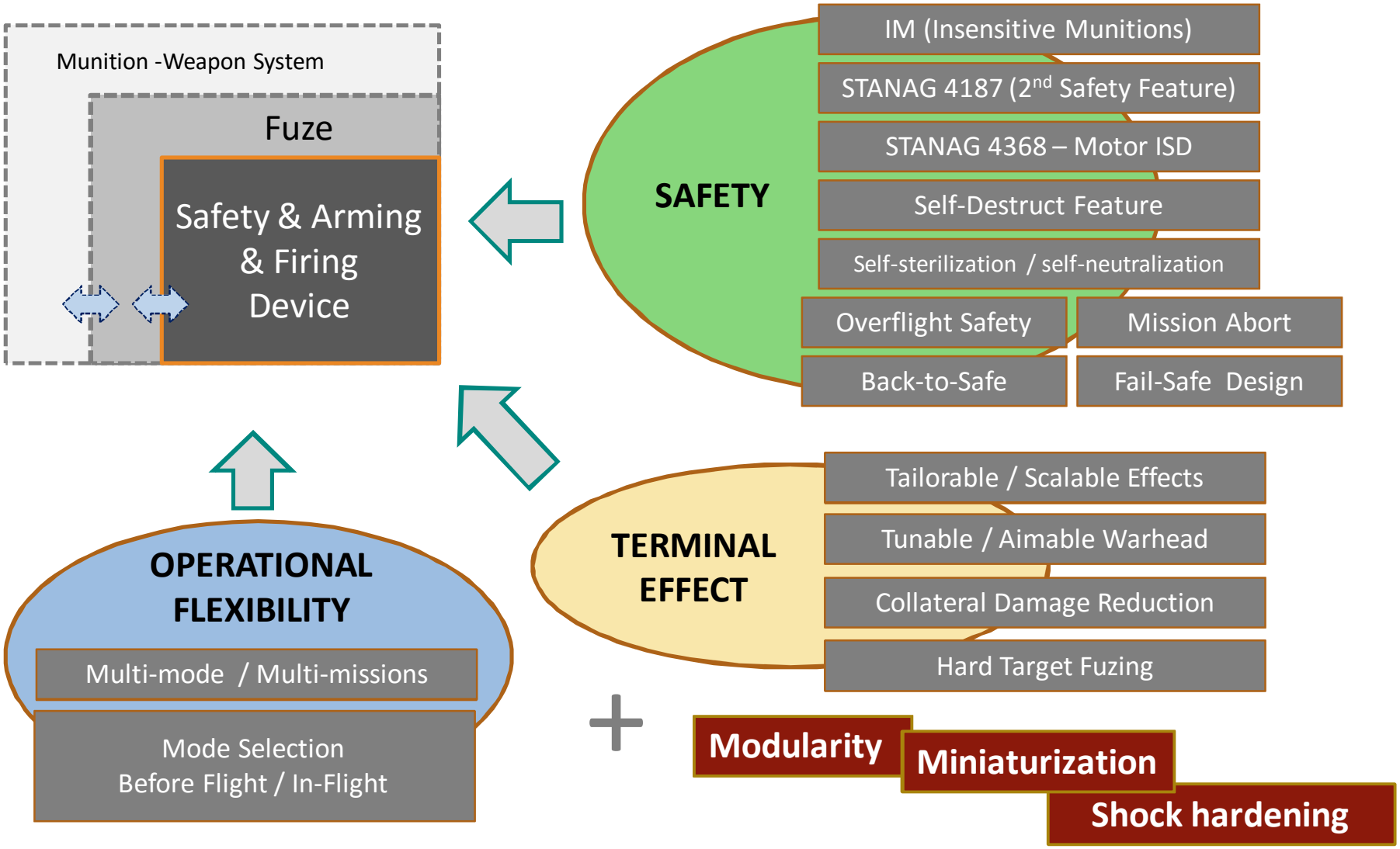

New Requirements – New Functions

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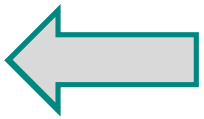
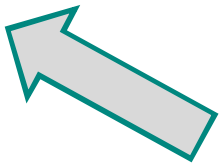
Need for a* Safety, Arming and Firing *Function

with

- **New Functionalities**
- **More Flexibility**
- **More Control**



- 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



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

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

Modularity

Miniaturization

Shock hardening

Electronically Controlled S&A Devices

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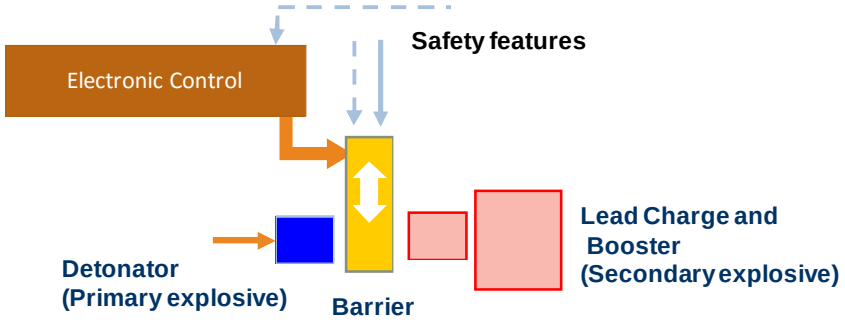
- New functionnalities
- Better control of arming / firing

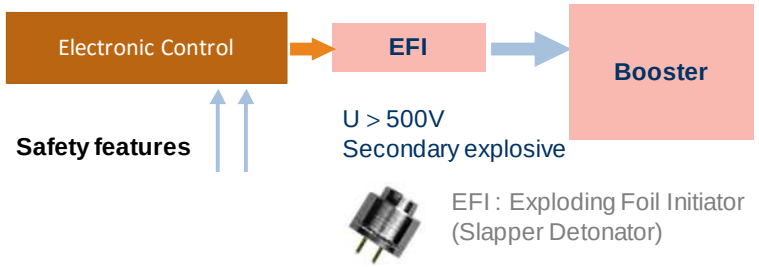
- Needs Electronic Control of the Safety & Arming Function

Electromechanical SAD (interrupted train)

Solutions

Electronic SAD (in-line)





Electronic S&A Device – Main components

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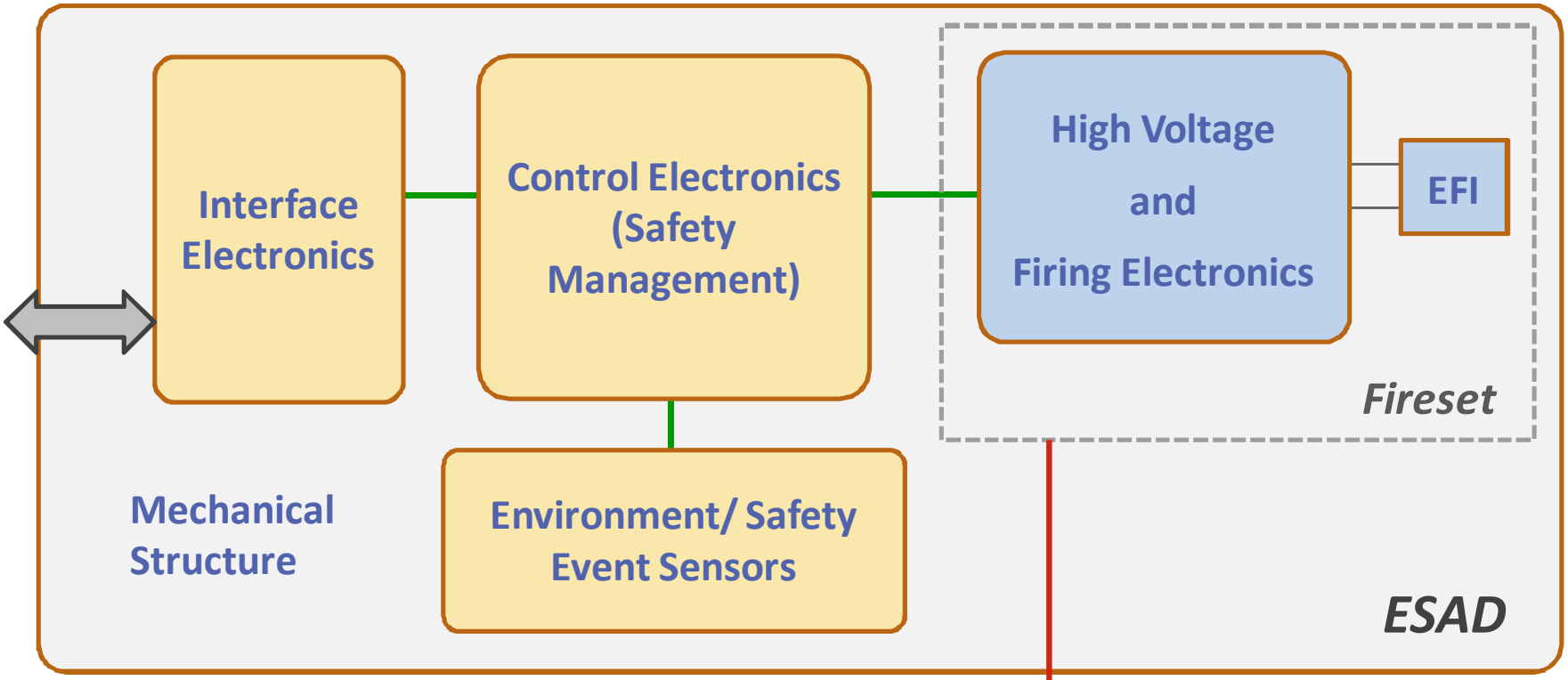
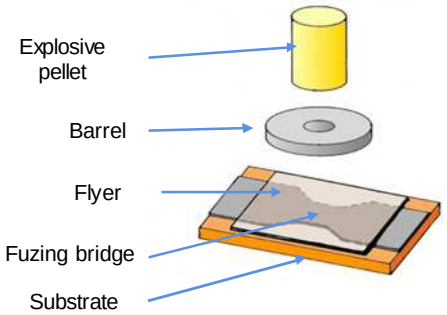


EFI (Exploding Foil Initiator)
Slapper Detonator



Key components of the fireset

- **EFI**
- **HV capacitor**
- **HV switch**
- **Voltage converter**

Electronic Safety and Arming Technology - Main Benefits

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- 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

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VT1 ESAD

ASTER ESAD

AS30LS ESAD

ASTER (2) ESAD

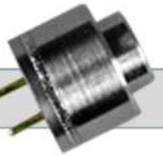
FBM21 Bomb Fuze

Heavyweight Torpedo Fuze

FBM21 Upgrade (LEEFI)

1990 2000 2010 2015

Plug-in EFI



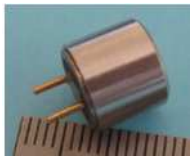
French MoD contract awards for LEEFI development

SCB LEEFI research (MCM ITP FR-UK)

LEEFI study start (PV)

Strip line EFI

LEEFI dev.



1990 2000 2010 2015

30 years experience in ESAD and slapper detonators

LEEFI-based SAD

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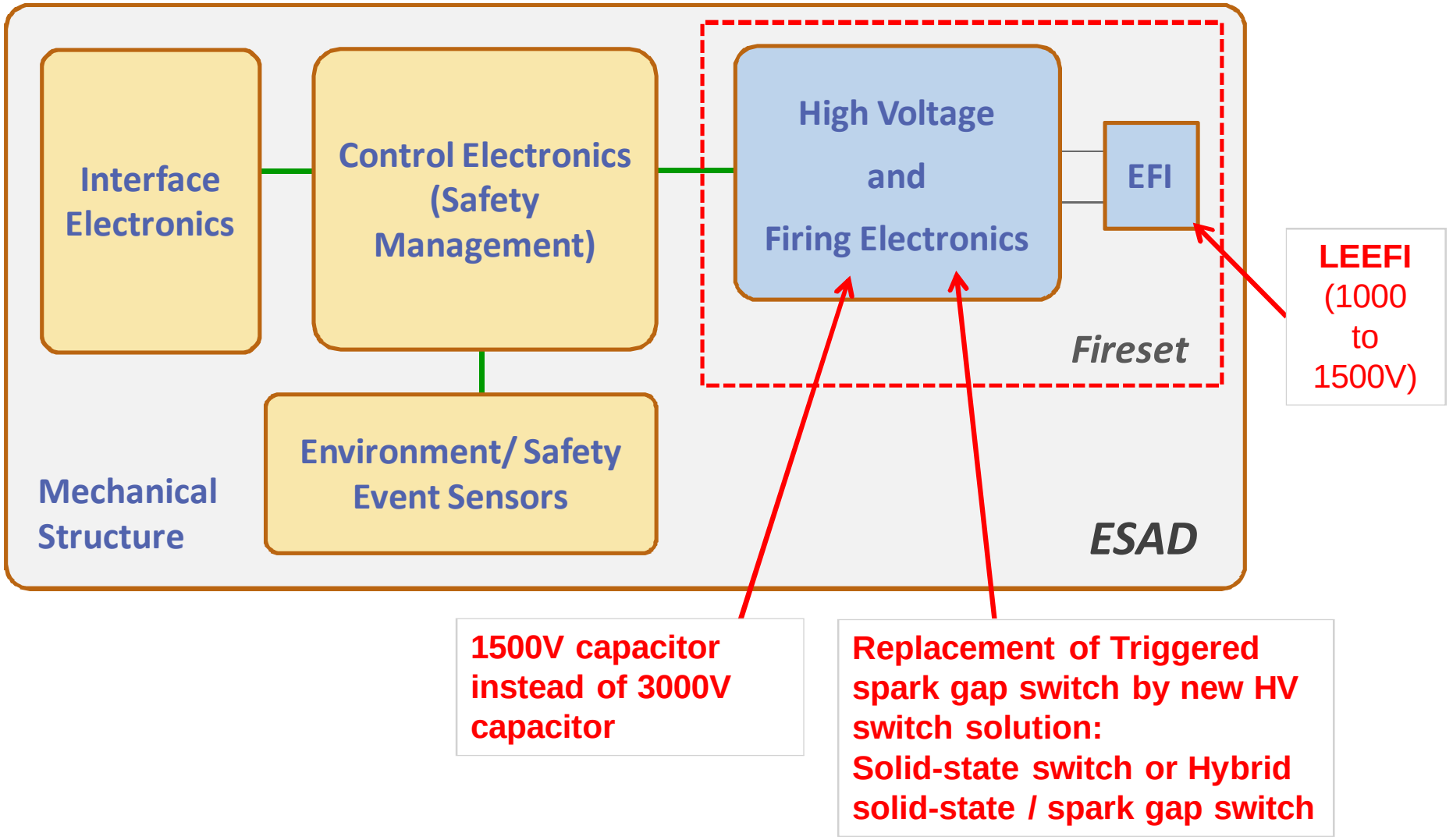

LEEFI Based Fireset and ESAD

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- **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

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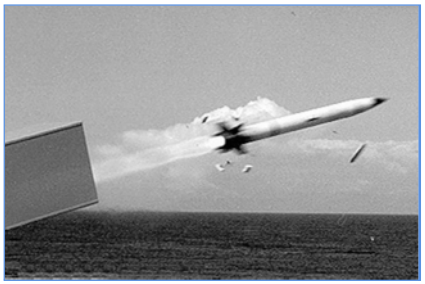
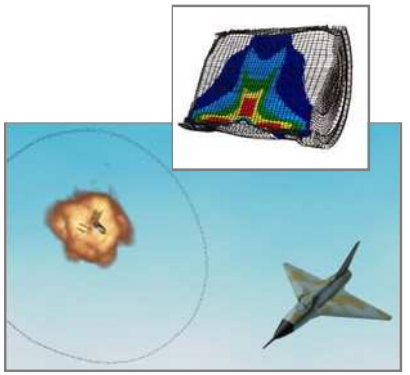
- **Rocket Motor Ignition**
  - STANAG 4368 compliance
  - Possibility of multi-pulse ignition (dual stage motor)
  - Possible use of TBI (through bulkhead initiation device) or direct ignition of propellant
  - Adaptation to various form factors



- **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

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- **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)

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- **French MoD (DGA) support to LEEFI based ESAD through <u>two R&D contracts</u>**
  - **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

DGA

- **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

Main Achievements
LEEFI

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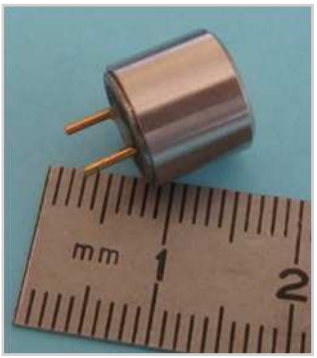
- **LEEFI design: Validation of the main parameters**
  - Expected operating voltage achieved
  - Bridge dimensions and thickness (copper bridge)
  - Flyer material and deposition process
  - Explosive material compound (HNS-IV + binder)
  - Mechanical integration
  - Bridge chip connection
  - Plug-in 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 paramaters, in consistency with the various components of the fireset
  - STANAG 4560 characterization



Plug-in LEEFI

Wafer with more than 1000 bridges / flyers

LEEFI design is validated with the whole spectrum of specifications

Main Achievements
Fireset Main Components

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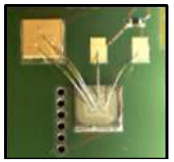
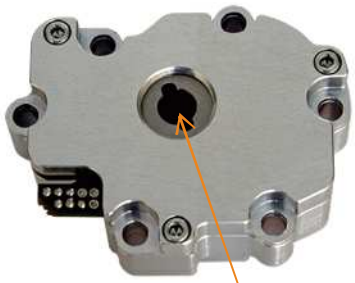
- **High-Voltage Switch: Assessment of various options**
  - COTS solid-state components, including "one-shot" components: possible but main drawbacks and risks
    - Option rejected
  - Design of a new silicon switch (MOS technology) from European founder:
    - Good results obtained with industrial 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**



Silicon Switch



Fireset Module

Key components of the Fireset have been fully validated

Main Achievements
Fireset Module

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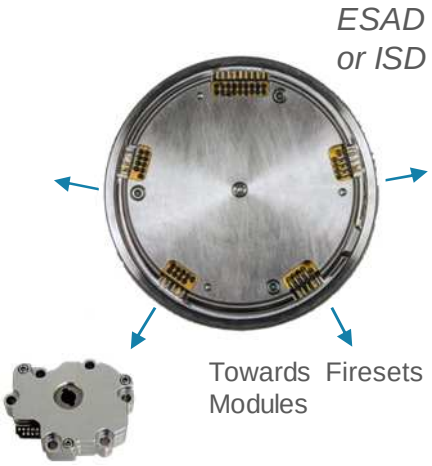
- **Fireset module**
  - Designed in view of distributed multi-point initiation, in the frame of these projects
  - Link with ESAD Control Electronics is carried out by low-voltage connection
  - Tested under high-shock condition (hard target penetration)



- **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

Firing of LEEFI igniter (for propellant)

Design adaptable to various ESAD/ISD configurations

Hard Target - Shock Test

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Video

Main achievements
Complete ESAD

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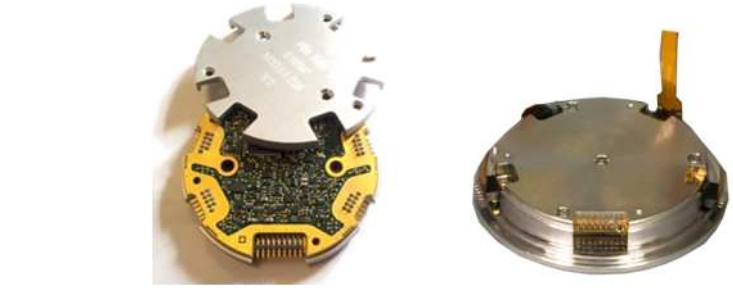
- **ESAD, carried out in the frame of the running programs, incorporate safety control electronics, mission management and interfaces electronics**
- **Two ESAD versions, based on similar basis, have been developped, and adapted to the specific requirements**
  - 1- with 6 fireset modules (multipoint 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**



LEEFI-based ESAD, compliant with STANAG 4187 and 4368, tested in operational munition environment

LEEFI Technology Activity - Next Steps

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- **End 2015: French MoD awarded a contract to JUNGHANS for an upgrade of FBM21 aerial bomb fuze, to implement additional functionnalities 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

FBM21 Bomb Fuze

FBM21 Electronic Module including Fireset

- **JUNGHANS product range extension: new missile or munitions warheads ESAD and rocket motors ISD (including multi-point initiation) based on LEEFI technology**

Conclusions

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- **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

JUNGHANS Microtec GmbH
Unterbergenweg 10
78655 Dunningen
Germany
Phone +49 7402 181-0
Fax +49 7402 181-400

JUNGHANS T2M SAS
Route d´Ardon
45240 La Ferté Saint Aubin
France
Phone +33 23851 6422
Fax +33 23851 6835

www.junghans-defence.com
E-Mail: info@junghans-defence.com