

Proximity Sensor Technologies Application to New Munitions



NDIA 58th Annual Fuze Conference
Baltimore - July 7-9, 2015
"Fuzing in a Challenging Environment"

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- **Proximity fuzes – product types**
- **Technology evolution**
- **Signal processing**
- **Proximity Sensor Modules for munitions**
 - HoB mode
 - Air-defence mode
- **Possible applications**
- **Integration challenges and solutions**

JUNGHANS Defence – The Fuze Company



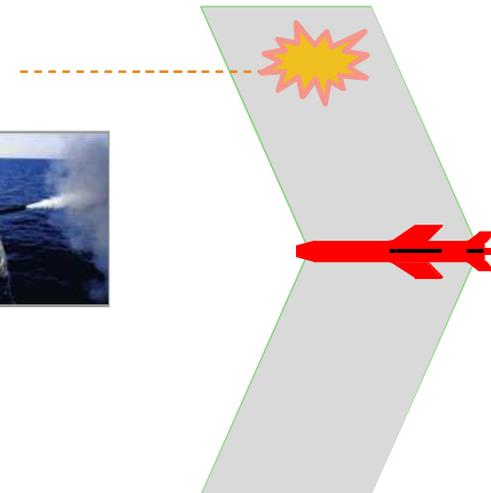
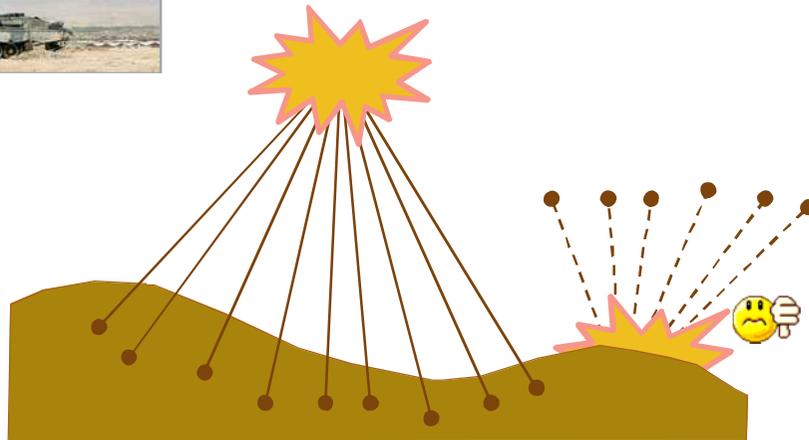
Complete range of fuzes for all types of munitions

Key competences in Fuzing technologies,
Micro-technologies and Ammunition electronics



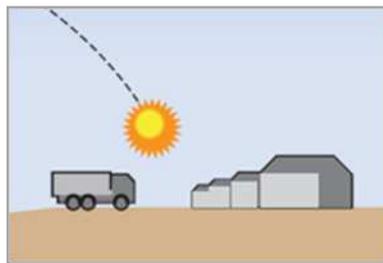
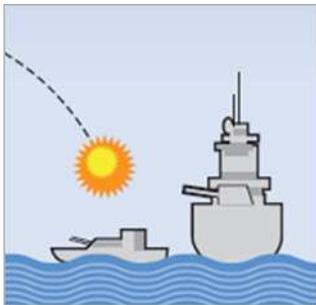
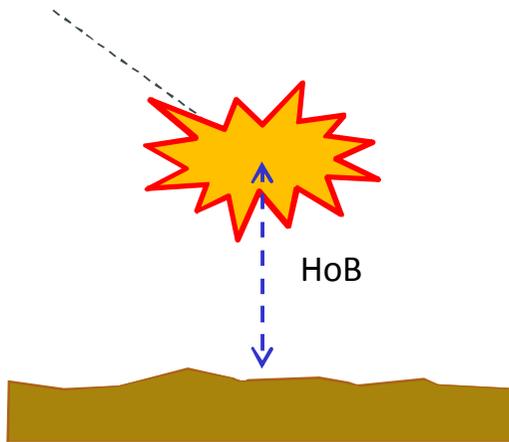
Proximity Fuzing – Key Feature for Munition Effectiveness Improvement

- Since the end of WWII the operational benefits provided by the use of proximity fuzes in modern warfare are clearly recognized
 - Significant increase of the **terminal effect** (firing on ground targets)
 - Significant improvement of the **hit and kill probability** (air defence)



Proximity Fuzes : Height of Burst Mode

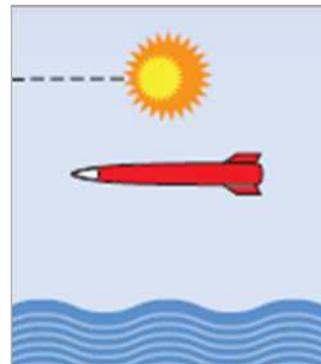
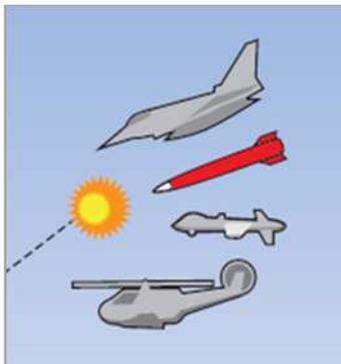
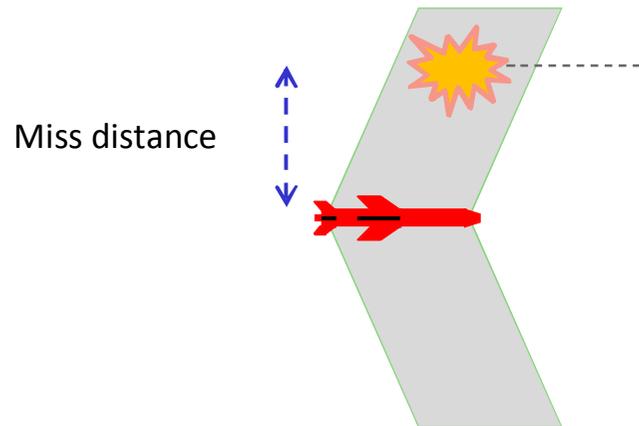
- **Surface targets (land or sea)**
 - Indirect fire, ground-to-ground and air-to-ground weapons



Artillery Multifunction Fuze firing test (live round)

Proximity Fuzes : Air Defence Mode

- **Aerial targets**
 - Naval artillery, air defence artillery and weapons

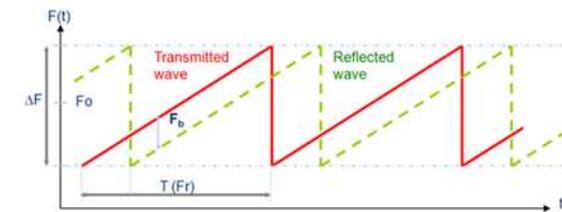


FREMEN Naval Artillery Fuze firing test (no explosive munition, booster only)

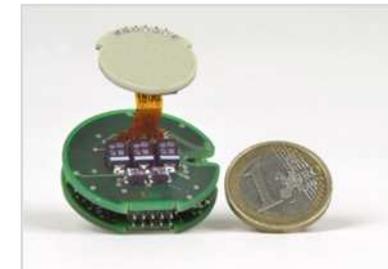
Proximity Fuzes for Munitions

Major Improvements in the Last Decade

- **Functioning principle**
 - FMCW radar (Frequency Modulated Continuous Wave):
Ability to measure the exact distance fuze-target
- **Technology**
 - Digital signal processing
 - Microwave electronics
 - High integration (electronic and antenna)
- **Size and power consumption compatible with the constraints of volume, energy and costs for munition fuzes**
- **Higher performances in target detection**
 - Better precision
 - Better resistance to ECM

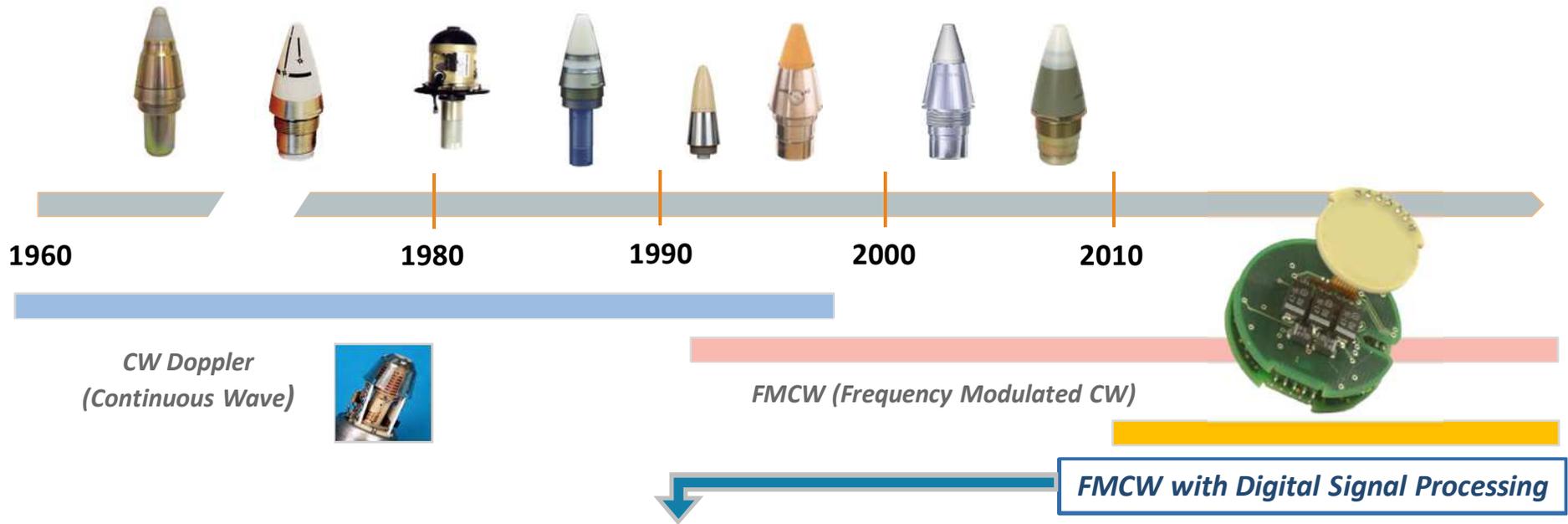


$$F_b = 2 \cdot h \cdot \Delta F / (c \cdot F_r)$$



New technologies provide better detection performances and better suitability for use in various type of munitions

Proximity Fuze Technology



*CW Doppler
(Continuous Wave)*



FMCW (Frequency Modulated CW)

FMCW with Digital Signal Processing

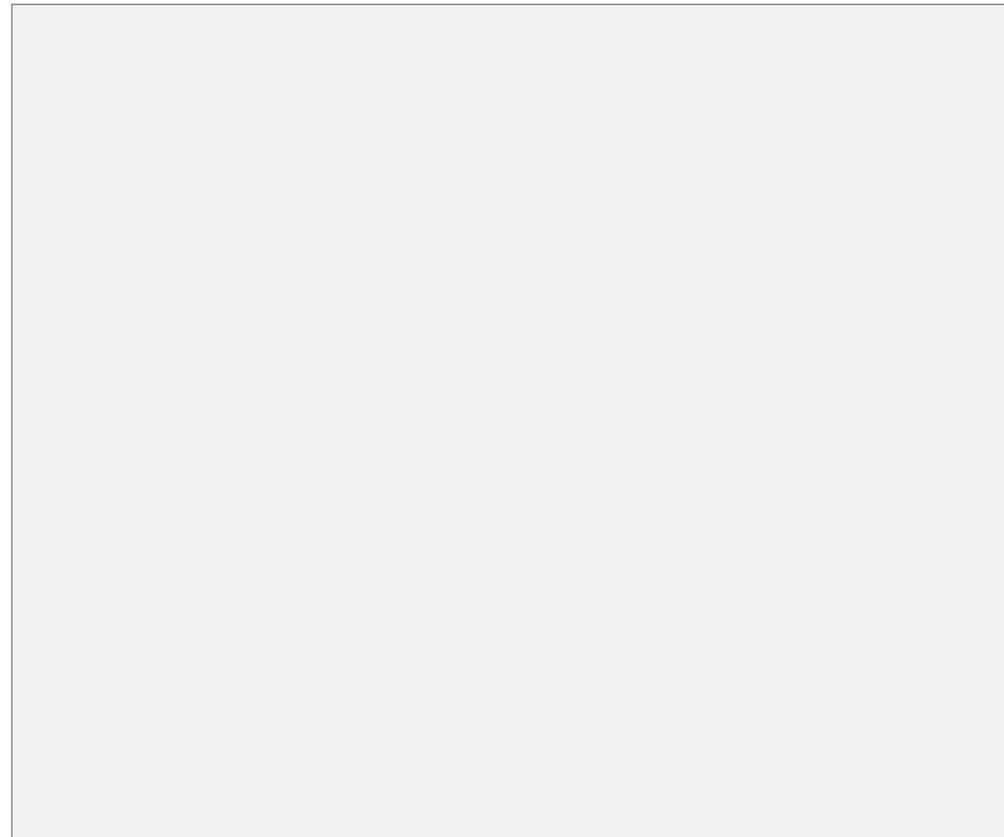
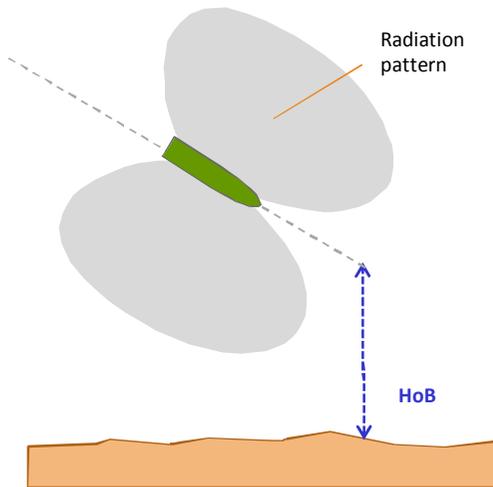
Now implemented in other proximity fuzes and proximity sensors

A collection of images showing various applications of the FMCW with Digital Signal Processing technology. From left to right: a Course-Correction Fuze (SPACIDO), two different Mortar (FLAME) fuzes, two different Naval Artillery (FREMEN 100 and 76) fuzes, a Field Artillery and Rifled Mortar (FURYA) fuze, an Aerial Bomb fuze, and a Guided A/G weapon (AASM/Hammer from SAGEM). To the right of these images is the text "... + others".

HoB Sensor – Signal Processing

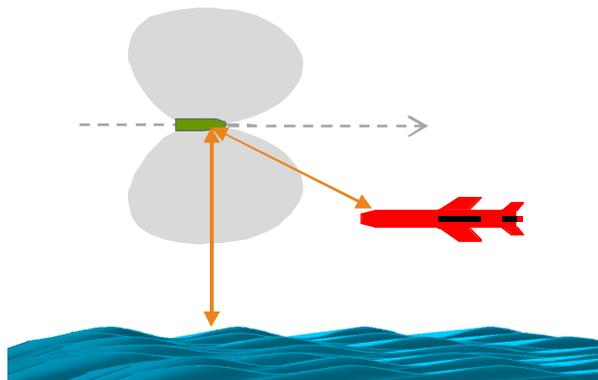
- **Spectrum analysis**
 - Distance analysis (range bin / target-sensor distance)
 - Doppler analysis
- **Tracking of the measured distance and coherence analysis**

Video – Spectrum analysis and Ground detection

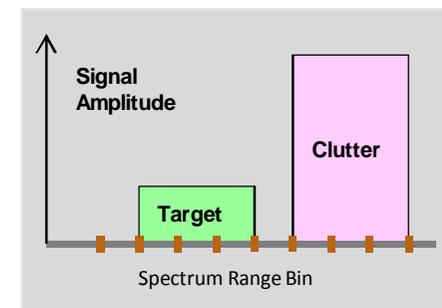
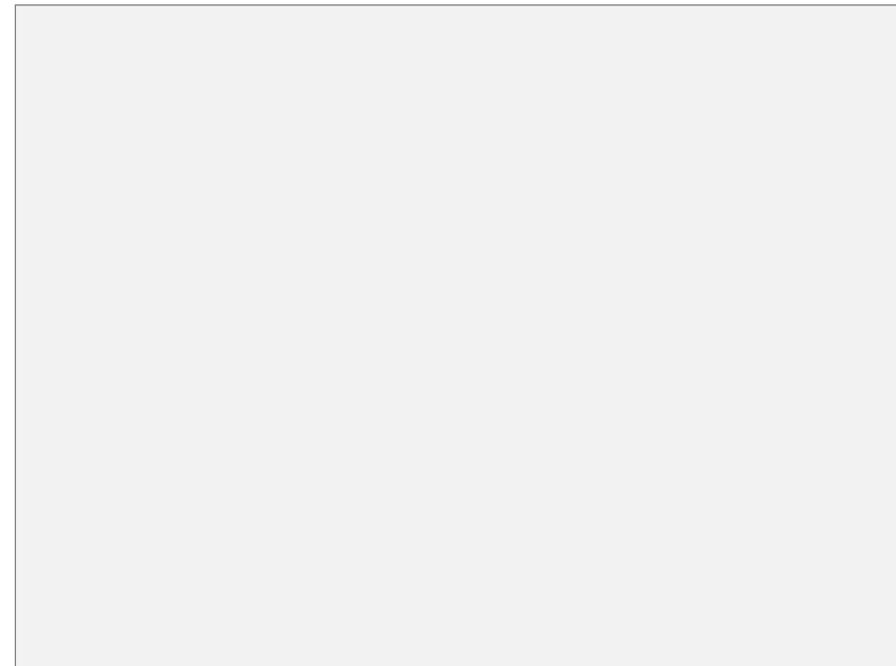


Aerial Target Detection – Signal Processing

- **Spectrum Analysis: Extraction of the target parameters**
 - Target distance information
 - Speed - from the Doppler frequency shift
 - Radar cross section - from the signal level
- **Target clutter discrimination**
- **Range gated processing to isolate sea-clutter from valid targets**



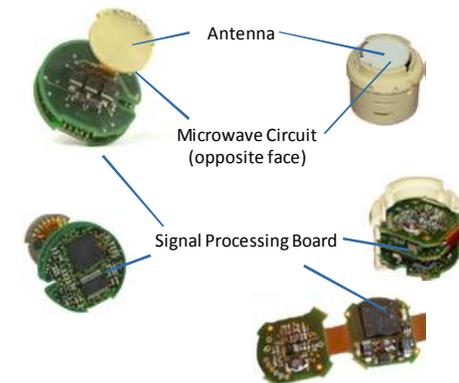
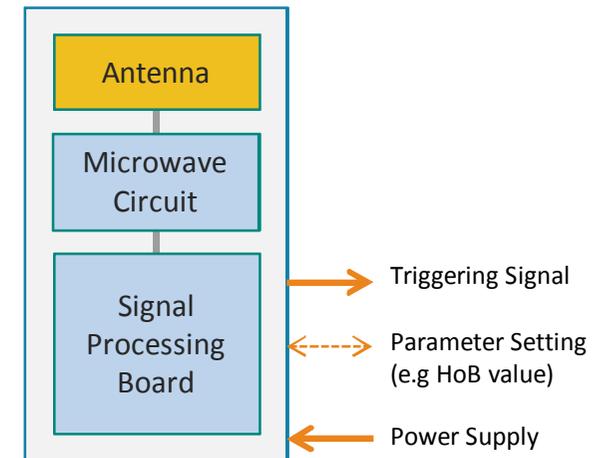
Video – Spectrum analysis – target detection



Proximity Sensor Module for Use on other Fuze, Munition or Missile

- **Objective:** Leverage technology and design from artillery proximity fuze sensors for implementation in other munitions/weapons
- **Proposed product:** Advanced miniaturized radar sensor, based on FMCW principle, with full digital signal processing
 - Single module incorporating all functions
 - Re-use of electronic design
 - Antenna design: adapted to specific radiation pattern needs
 - Specific arrangement of the sub-assemblies depending on the application: layout, integration, housing and interfaces
 - Compatible with extreme environmental conditions from munitions and missiles

Proximity Sensor Module



New proximity sensor technology makes "customization" easier

Proximity Sensor Module 1 (HoB Mode) Main Features

- HoB sensor, based on the artillery and mortar fuze sensor designs
- FMCW radar
- HoB range: from 3m to 30m or higher.
HoB can be set to different values
- Operation from velocity ranging from 50m/s to more than 1000 m/s. Approach angle from 5° to 90° (depending on antenna design)
- Performance independent from the target surface reflectivity (water, sand, rocks, snow,...)
- Electronic board size: ca. 20 to 30cm²
Possibility of various arrangements
- Antenna: patch antenna



*Design Basis :
FRAPPE Fuze Sensor*



**Sensor performances proven in artillery fuzes used in operation
On-going programs for use on air-to-ground weapons**

Proximity Sensor Module 2 (Air Target)

Main Features

- **Optimized for both Air-Defence and HoB modes.**
Based on the naval artillery fuze sensor design
- **Processing capability more powerful than Sensor 1 as signal processing requires much higher performance**
- **Electronic board size: ca. 30 to 40cm²**
Possibility of various arrangements
- **Target detection capability**
 - Aircraft, helicopter, diving or sea-skimming missile, UAV
 - Stationary target or mobile target, up to Mach 2
 - Miss distance: 5m to 8m depending on the type and on the configuration of the target.
- **Possible design adaptation to meet specific application requirements and target attack configurations**



*Design Basis :
FREMEN Fuze Sensor*

**Sensor performances proven in naval artillery fuze application
(FREMEN 100 and FREMEN 76 in qualification process)**

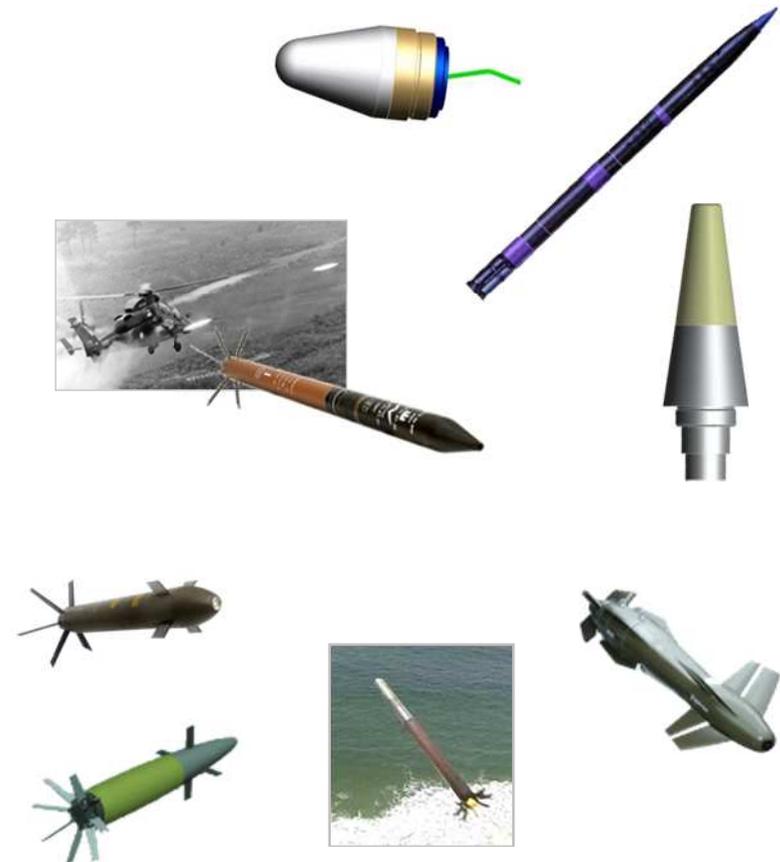
Proximity Sensor Module Implementation in Modern Munitions

- **Main issues and challenges**
 - Integration in munitions which have not been initially designed to incorporate a proximity function
 - Antenna location in the munition: essential to achieve good performance of the sensor
 - Other compatibility issues : ballistics, extreme flight conditions, EMC with other equipments
 - Low cost
- **The Proximity Sensor Module design must be flexible enough to be adapted to specific munition configurations**
 - Sub-assembly arrangements according to available space and interfaces

**Leverage existing design but keep adaptability
to meet various munition configurations**

Possible Applications for Proximity Sensor Modules

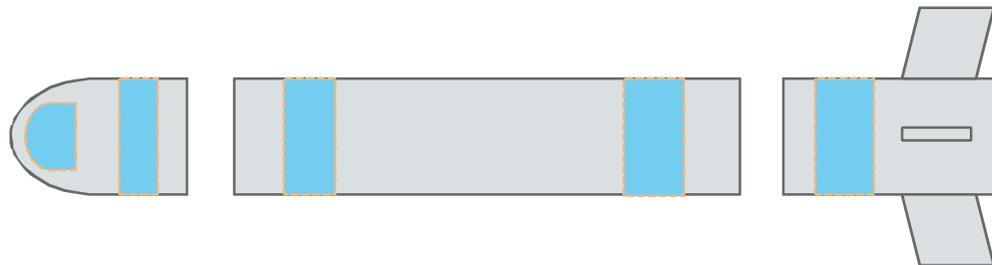
- **Conventional munitions or fuzes, not yet fitted with proximity mode**
 - e.g. air-to-ground rockets, artillery rockets, air-to-ground weapons, air-defence and C-RAM munitions
- **New generation guided munitions and correcting or guidance kits**
 - artillery, mortar, rockets or airborne weapons
- **Small and "low-cost" missiles,**
 - in the domain of land warfare or air-defence.



The module's cost and versatility enable its use in various applications

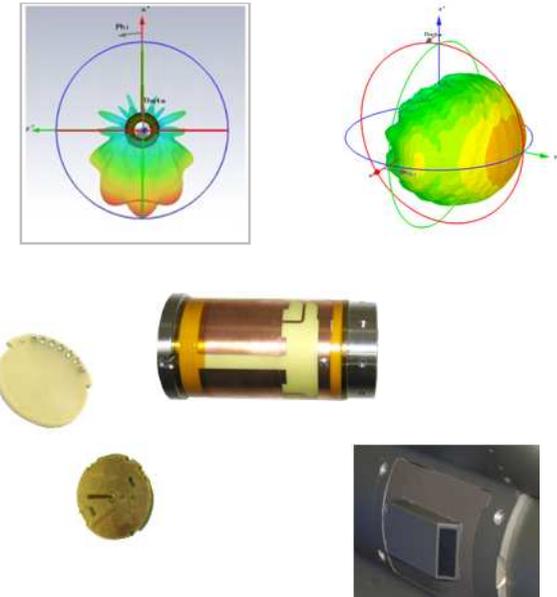
Proximity Sensor Module Integration - Constraints

- **Nose cone section**
 - The most suitable location for the proximity sensor operation
 - However, often no available space: fully packed with other devices (Seeker, Guidance Navigation and Control systems)
- **Main body section or tail section**
 - Impact on the munition frame
 - Aerodynamics
 - Integration and interconnection

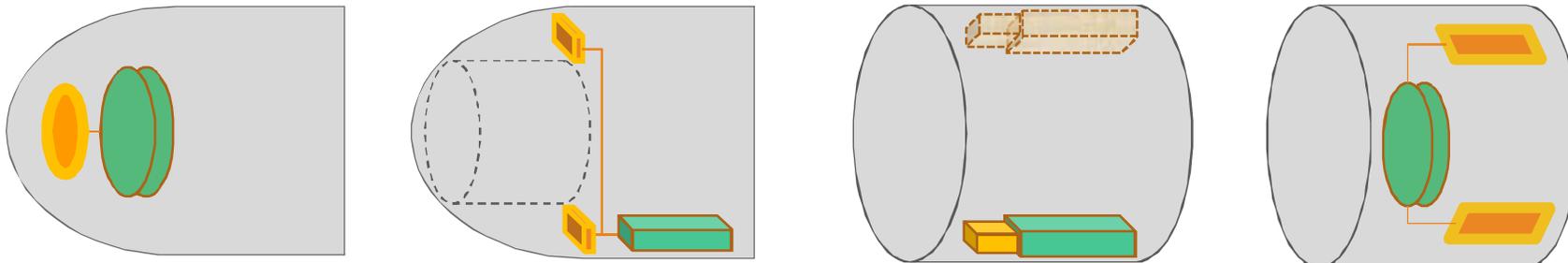


Proximity Sensor Module Integration Solutions

- **Possibility to tailor antenna and electronic sub-assemblies to cope with integration constraints, either in nose part, main body or tail sections**
 - Use of patch and conformal antennas, optimized to achieve suitable radiation pattern
 - Specific Electronics layout and arrangement to fit internal configuration of the munition



 Signal Processing Electronics  Antenna



Miniaturization provides solutions to meet specific integration constraints

- **Target proximity sensing is a key feature which dramatically improves fuze performances and munitions terminal effect**
- **New technologies enable the provision of sophisticated and powerful proximity sensors, entirely compatible with the constraints of volume, energy and costs for munition fuzes**
- **JUNGHANS Defence is now proposing this technology, qualified and proven in fuzes for field and naval artillery, to achieve **low cost, reliable and effective** proximity sensor solutions for any modern conventional and guided munitions**

Thank you for your attention.

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