New Generation Naval Fuze FREMEN
Efficiency against New Threats

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Naval Artillery Warfare and Munition Fuze Requirements

FM-CW Proximity Sensor Technology

FREMEN Fuze Introduction

New Threats / New Targets in Naval Warfare

Fuze Performances on Specific Targets

Summary
Complete range of fuzes for all types of munitions

Key competences in Fuzing technologies, Micro-technologies and Ammunition electronics
Past and recent conflicts have stressed the importance of naval artillery use

- Renewed interest for naval artillery as a cost effective and flexible way to deliver terminal effect on various threats

Main requirements

- The two usual main operational missions:
  - Naval Fire Support - Shore bombardment
  - Air Defence - anti-aircraft / anti-missile

- + asymmetric warfare requirements, in particular in close-quarter engagement

The operational capability and efficiency of naval artillery and naval munitions are largely driven by the fuze performance

- Multifunction / Proximity Fuzes
Naval Artillery - Electronic Fuzes

Main Operational Missions

Air-Defence Role

Proximity / PD Fuzing for aerial target attack

Fire Support Role

Proximity / PD Fuzing on surface target (HoB)
Naval Artillery - Electronic Fuzes
Proximity Modes

• **on surface targets**
  Height of Burst Mode

  ![Diagram of Height of Burst Mode](image1)

  **HoB**

• **on aerial targets**

  ![Diagram of Miss Distance](image2)

  **Miss distance**

Significant increase of munition terminal effect and kill probability

Video: firing test on ground surface (live round)

Video: firing on dummy missile target (no explosive munition, booster only)
Improve the naval fuze proximity radar sensor capabilities

- Enable the detection of a various set of targets in various attack configurations, in particular:
  - Slow moving targets, or very high-speed targets
  - Low-altitude flight
  - Low Radar Cross Section
  - In presence of sea clutter

- Precisely detonate the munition to achieve optimal terminal effect on targets
- Prevent any fuze triggering on external disturbances such as sea clutter or EM radiations (no early burst)

... while keeping

- Unit cost down
- High reliability - even when using sophisticated functionalities
- Operational flexibility and versatility - no system programming
**FREMEN** New Generation Naval Multifunction Fuze Family

- Developed in 2 calibers: 100mm & 76mm
- Ongoing contracts from French MoD for qualification and production
  - Qualification successfully achieved
- Adaptation to 127mm (5") caliber

- Fully autonomous fuze: no need for mode setting

- Based on common electronic module
Benefit from FM-CW Radar Sensor Principle compared with CW Doppler Fuzes

- Frequency Modulation
  - \( F_b = \frac{2D}{c} \cdot \frac{\Delta F}{T} \)
    - Beat Frequency \( F_b \) is proportional to the target distance \( D \)

- Target information provided by FMCW sensor
  - Radar Cross Section: from the signal amplitude
  - Relative target velocity: from the Doppler signal
  - \(+ Target distance\): from the beat frequency

- Extraction of the target parameters by spectrum analysis
  - Range gated processing to isolate sea-clutter from valid targets

FMCW sensor provides a key information on the target: its DISTANCE
Electronic Fuzes for Naval Artillery
Focus on New Threats

- High-speed, stealth Sea-Skimming Missile
- Autonomous or Guided Unmanned Aerial Vehicle
- Fast Inshore Attack Craft

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Detection of Low Radar Cross-Section Targets

- **Targets with RCS < 0.1m²**
  - Stealth anti-ship missiles
  - Autonomous or guided Unmanned Aerial Vehicle

- **Detection especially challenging in the following configurations:**
  - Low altitude target - sea-skimming configuration
    - Disturbance from sea clutter (radar-echoes from sea waves)
  - Low speed
    - in particular for CW Doppler fuzes, using only doppler signal difference

- **Benefits from FMCW + spectrum analysis / digital signal processing**
  - Ability to discriminate the target signal from sea-clutter
    - Continuous measurement of target distance – Beat frequency signal
    - Relative velocity measurement (if any) – Doppler signal
  - Even in adverse conditions
    - For small RCS targets
    - In presence of a strong sea clutter (rough sea state)
Detection of Low RCS targets
FMCW Sensor Performances

- Target signal extraction by spectrum analysis

FREMEN Fuze is able to extract low-RCS target from clutter
FREMEN Fuze - Qualification Firing Tests on Sea-skimming Missile

- Video: Proximity on target (Sea-skimming missile)
Terminal effectiveness of the munition is directly driven by the precise time of initiation of the explosive charge

- Effectiveness area: defined by various parameters
  - Target/shell relative velocity, fragmentation spreading pattern and velocity, missdistance, size of the target
  - Range of relative velocity (target vs munition) is very wide, from 0 to several mach numbers

**FREMEN fuze FMCW sensor is able to accurately measure both distance and relative velocity of the target**

- Provides the precise location of the munition over the target
- thus decides the optimum bursting point to achieve maximum effect

**FREMEN Fuze is able to actually define the optimum initiation time**
Fast Inshore Attack Craft Threat

- Fast Inshore Attack Craft (FIAC) threat is in the focus of many western navies
  - Difficult targets to defeat, in particular in case of "swarm" attack
  - Close-quarter engagement / Direct Fire configuration

- Modern Naval Artillery can be the suitable and optimal solution to achieve this specific ASuW operations
  - Low cost, flexible, quick reaction
  - Especially when using high performance munition / fuze to achieve optimal effect on target
Deliver effect against FIAC threat remains challenging for naval artillery

- Point Detonating munition or Time programmable airburst munitions:
  - Either very low hit probability or complex fuze programming with dedicated and expensive weapon system
- Proximity fuzing: very challenging in direct fire configuration

FREMEN new generation fuze is featuring a unique, major capability for naval engagement: **HoB mode on sea surface, in direct fire operation**

- FREMEN fuze incorporates dedicated algorithms to cope with this tricky configuration, achieving continuous trajectory measurement, providing accurate HOB and enhanced terminal effect
Proximity mode on surface / direct fire
FREMEN Fuze - Operational Modes
Fully Autonomous Operation

- FREMEN Fuze autonomously selects either air defence or surface fire mode
  - The sensor continuously analyses target signals and triggers as soon as a target is detected with valid criteria - either aerial target or surface target

- FREMEN Fuze is able to efficiently achieve a very broad range of missions without requiring programming operation prior to firing
  - Very versatile and flexible, useable on any weapon system, free from setting issue

SELF-DESTRUCT (when selected)

SURFACE HoB (long range – land or sea)

AERIAL TARGET DETECTION (high or low altitude)

HoB on SEA SURFACE / DIRECT FIRE (short range)
• Naval artillery fuzes have to meet demanding operational requirements, in particular with increasing new asymmetric threats

• JUNGHANS Defence is proposing the FREMEN new generation of multifunction fuze providing new capabilities to modern naval artillery

• FREMEN fuze is achieving unmatched detection performances. It enables to defeat a wide variety of targets, while operating fully autonomously without fuze programming

• FREMEN fuze technology can be provided in various naval artillery calibers
Thank you for your attention.

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