



New Generation Naval Artillery Multi-Function Fuze

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***56th Annual Fuze Conference
"Next Generation Fuzing for Next Generation Weapons"***

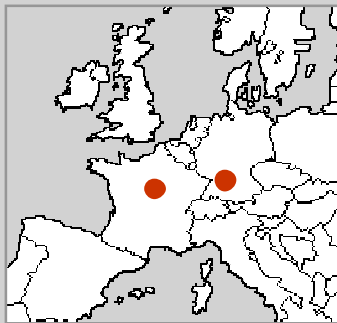
Baltimore, MD - May 14-16, 2012

Outline

- Proximity Fuze Technologies
- New Radar Sensor - Application to Naval Fuzes
- FMCW – Digital Signal Processing: Performances and Benefits
- New Generation Proximity Fuzes for Naval Artillery:
FREMEN 100mm & FREMEN 76mm
- Fuze Main Features and Design

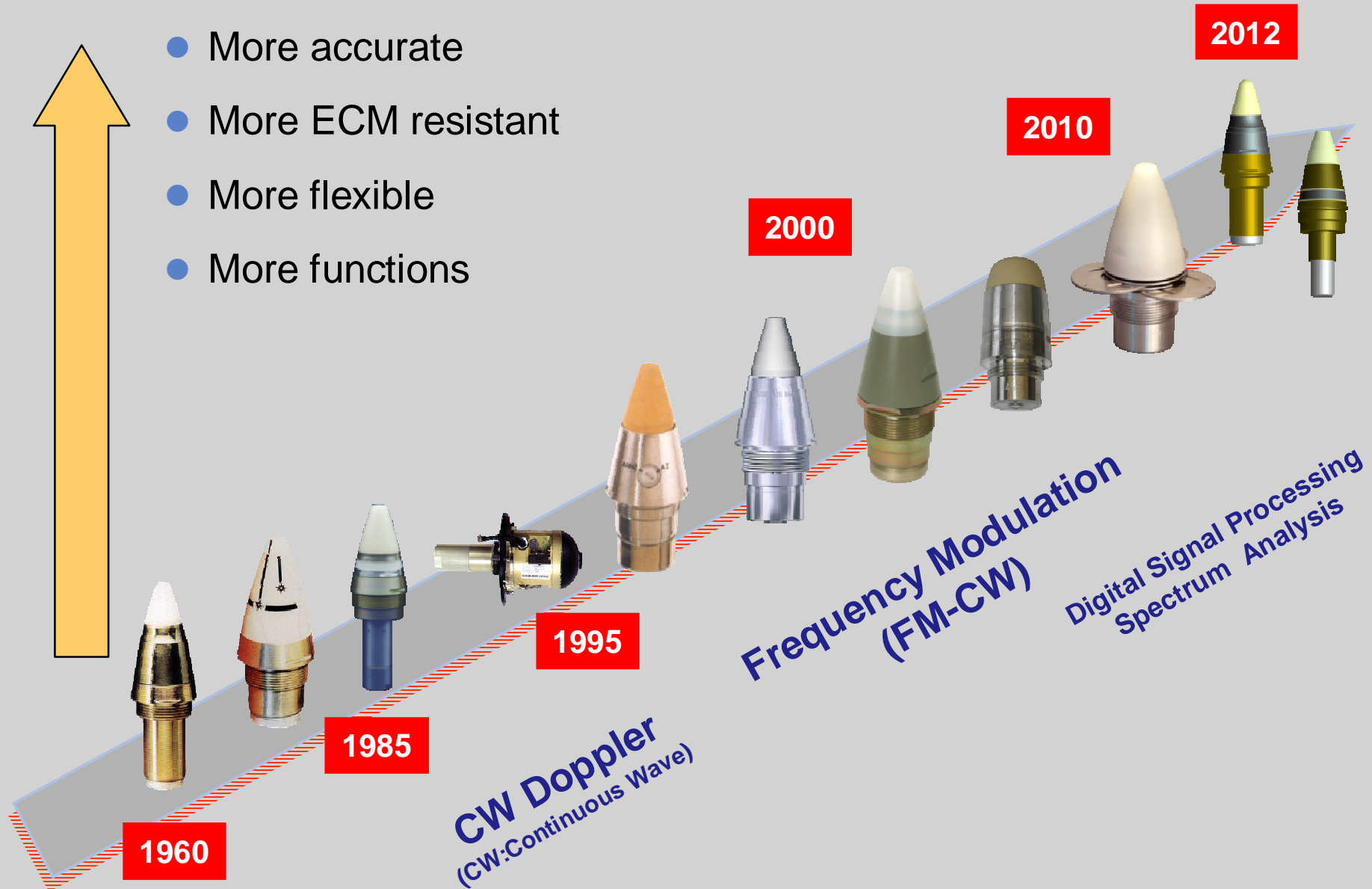
Company Presentation

- A leader in the field of ammunition fuzes and S&A devices
- Full range of products
- Key competences in
 - Fuzing technologies
 - Micro-technologies
 - Ammunition electronics



Proximity Fuze Background

- More accurate
- More ECM resistant
- More flexible
- More functions



1960

1985

1995

2000

2010

2012

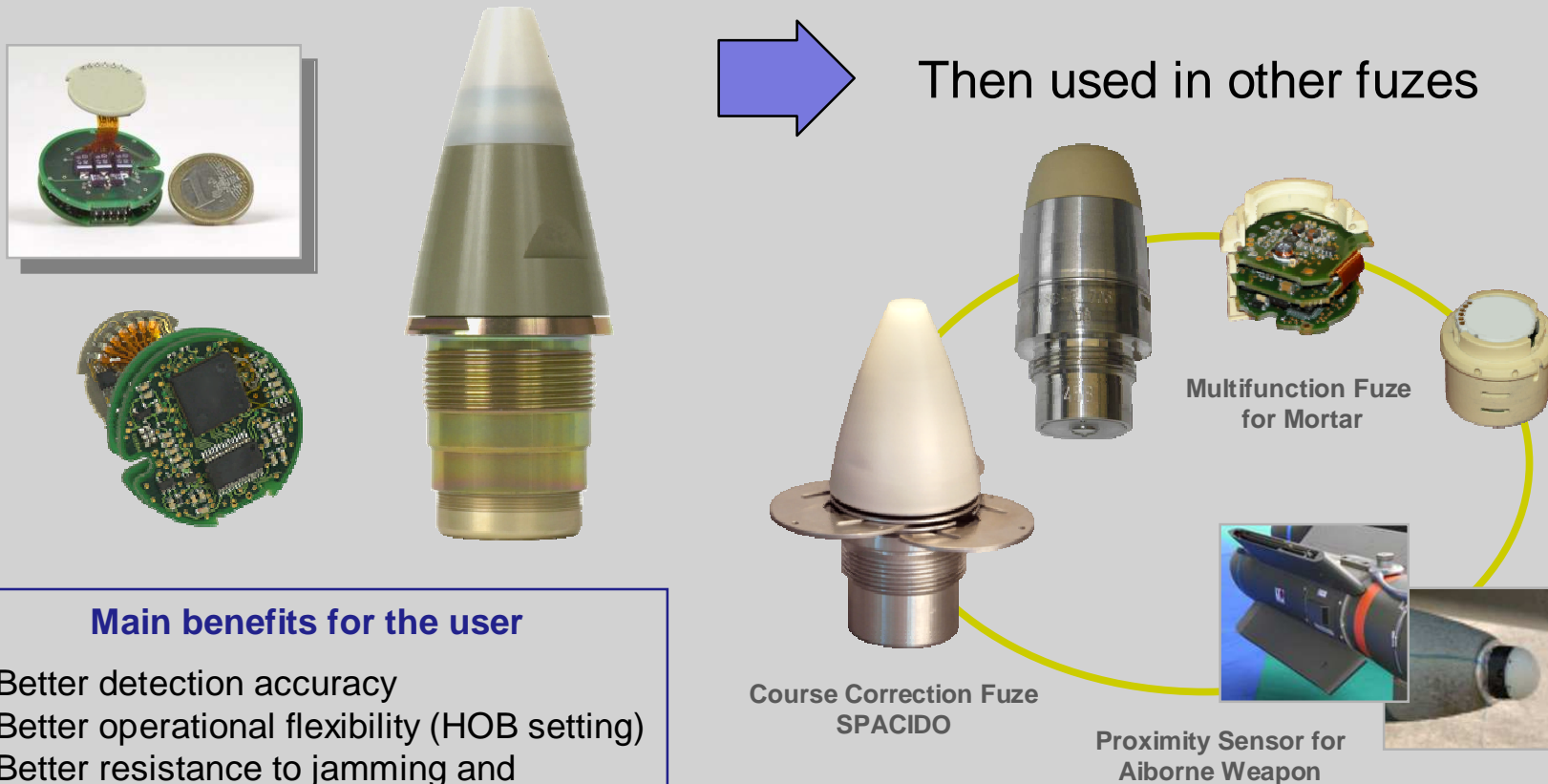
CW Doppler
(CW:Continuous Wave)

Frequency Modulation
(FM-CW)

Digital Signal Processing
Spectrum Analysis

New Generation Proximity Sensor

- New state-of-the-art proximity sensor developed by JUNGHANS and qualified in 2007 in the FRAPPE artillery multifunction fuze
 - **FM-CW Microwave Radar Sensor + Full Digital Signal Processing**

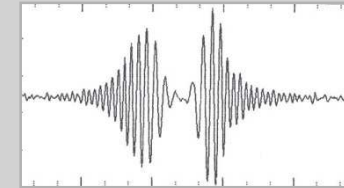
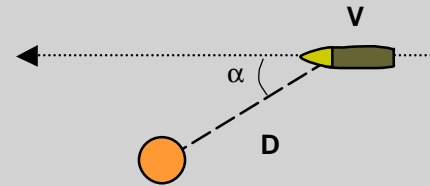


- Main benefits for the user**
- ▶ Better detection accuracy
 - ▶ Better operational flexibility (HOB setting)
 - ▶ Better resistance to jamming and electromagnetic countermeasures

Back to Basics

Conventional Air-Defence CW Doppler Fuze

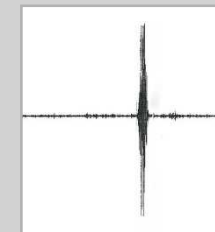
- $F_d = 2V/\lambda \cdot \cos \alpha$
- Target information provided:
 - Amplitude (radar cross section)
 - Relative target velocity (doppler)
- Main issue : separation of target and clutter, in particular for very low altitude target (sea skimming missile, helicopter, drones)



Target Signals After Filtering



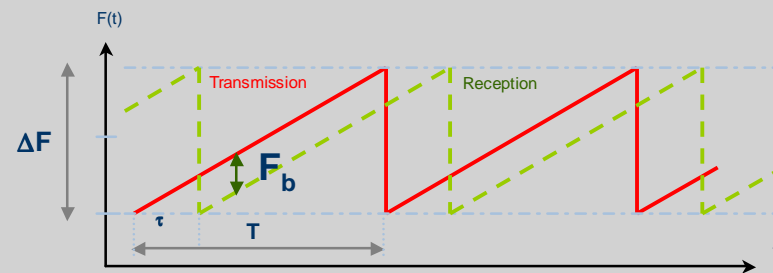
Low Altitude Target



Medium Altitude Target

FM-CW Radar Sensor Principle

- $F_b = 2D/c \cdot \Delta F / T$
- ⇒ F_b is proportional to the target distance D
- Target information provided:
 - Amplitude (radar cross section)
 - Relative target velocity (doppler)
 - **Target distance**

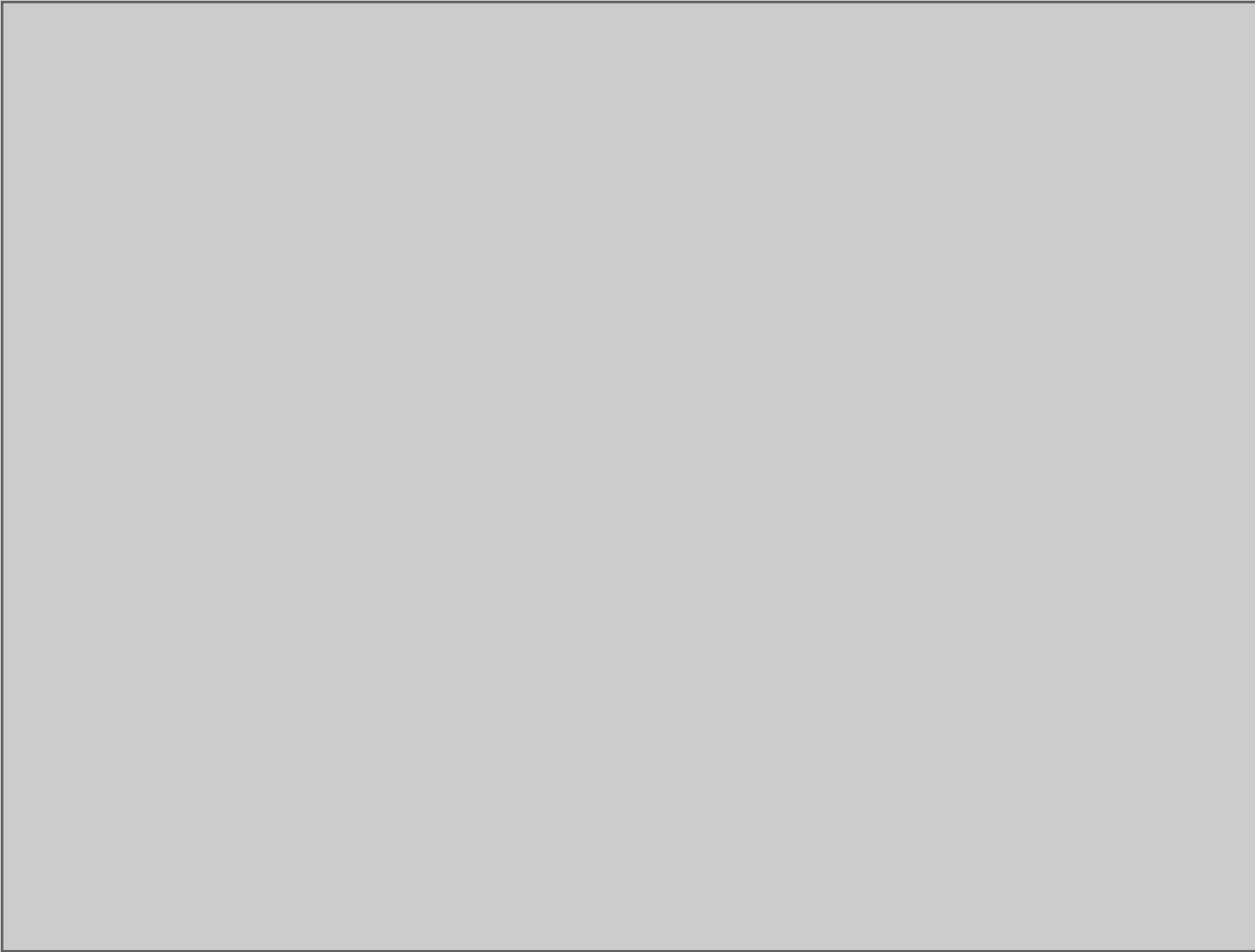


FMCW sensor provides a key information on the target: its DISTANCE

New Sensor – Application to Naval Fuzes

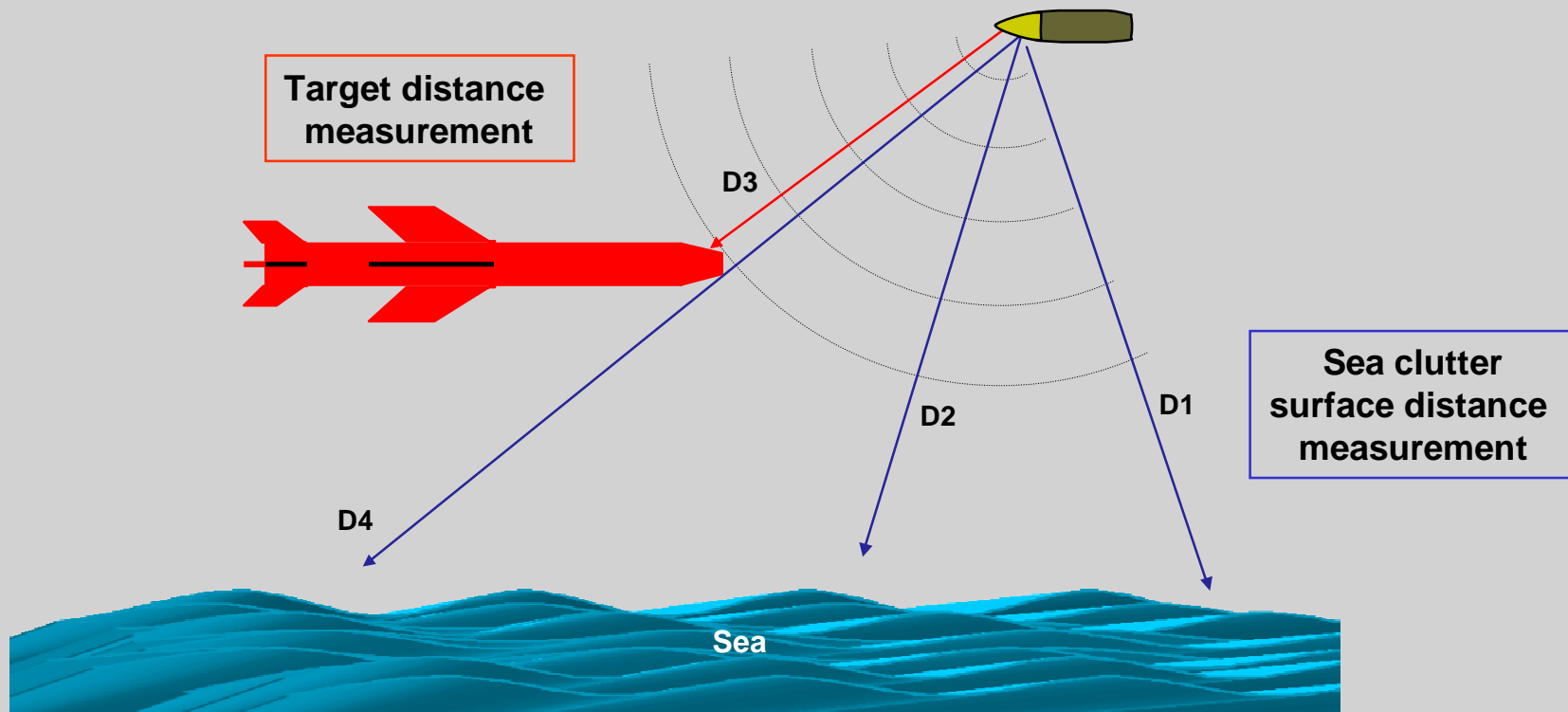
- **Main Objective:** Improve air-target detection performances
 - Increase the ability to detect a flying target in difficult conditions, in particular with stormy sea conditions (e.g sea skimming missile)
 - Reduce the false alarm rate (early burst)
 - Enhance the resistance to electromagnetic disturbances and countermeasures
 - Improve the capability to attack surface targets (sea and land)
- **Solution:**
 - Use the new generation FMCW radar sensor technique together with appropriate digital signal processing
- **Main challenges:** Overcome specific aerial target configurations
 - Very low target Radar Cross Section
 - Very high interception speed
 - Sea clutter disturbance

Video



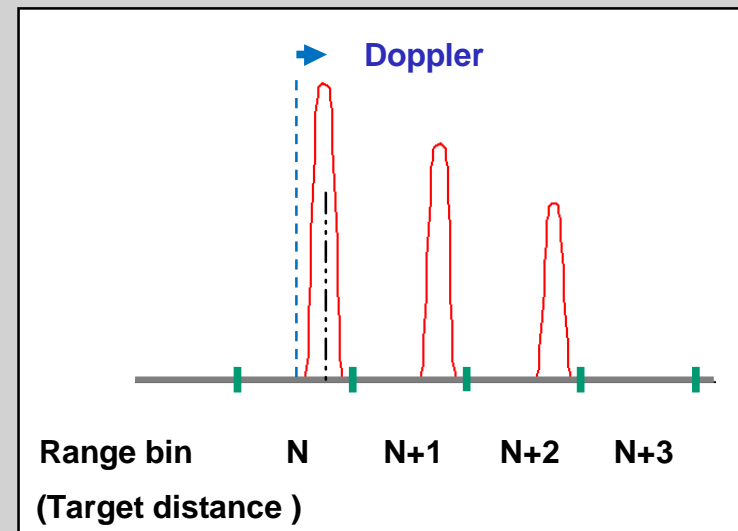
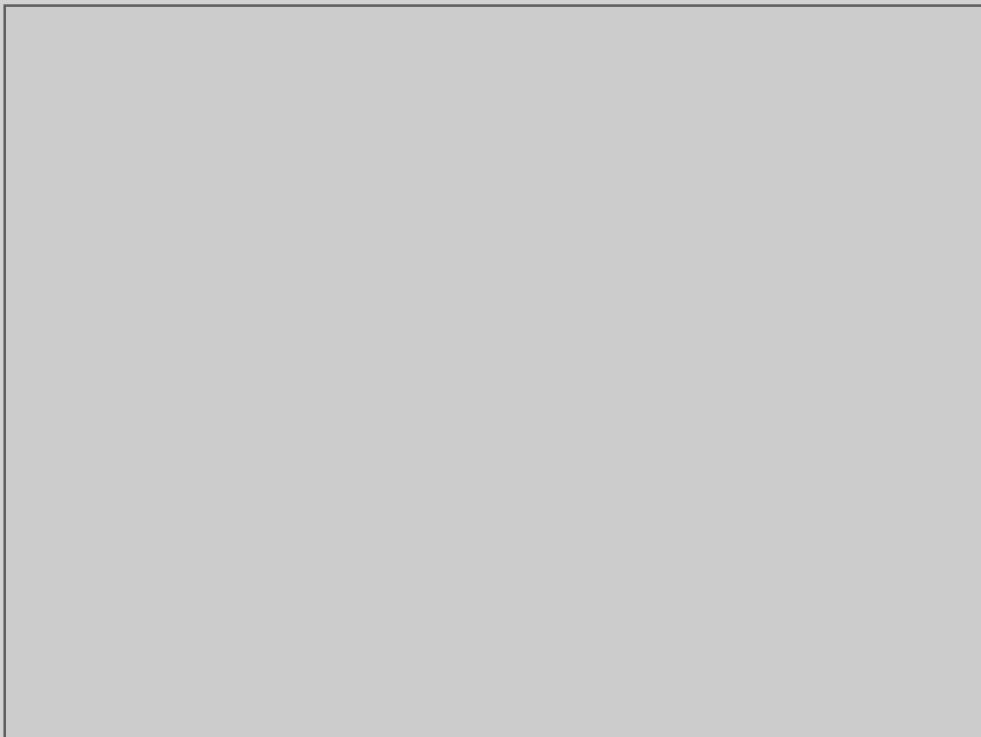
Target / Clutter Discrimination

- FMCW + Spectrum Analysis
- ⇒ Processing of the different target echo ranges
 - Allows discrimination between reflected signals:
Range gated processing to isolate sea-clutter from valid targets

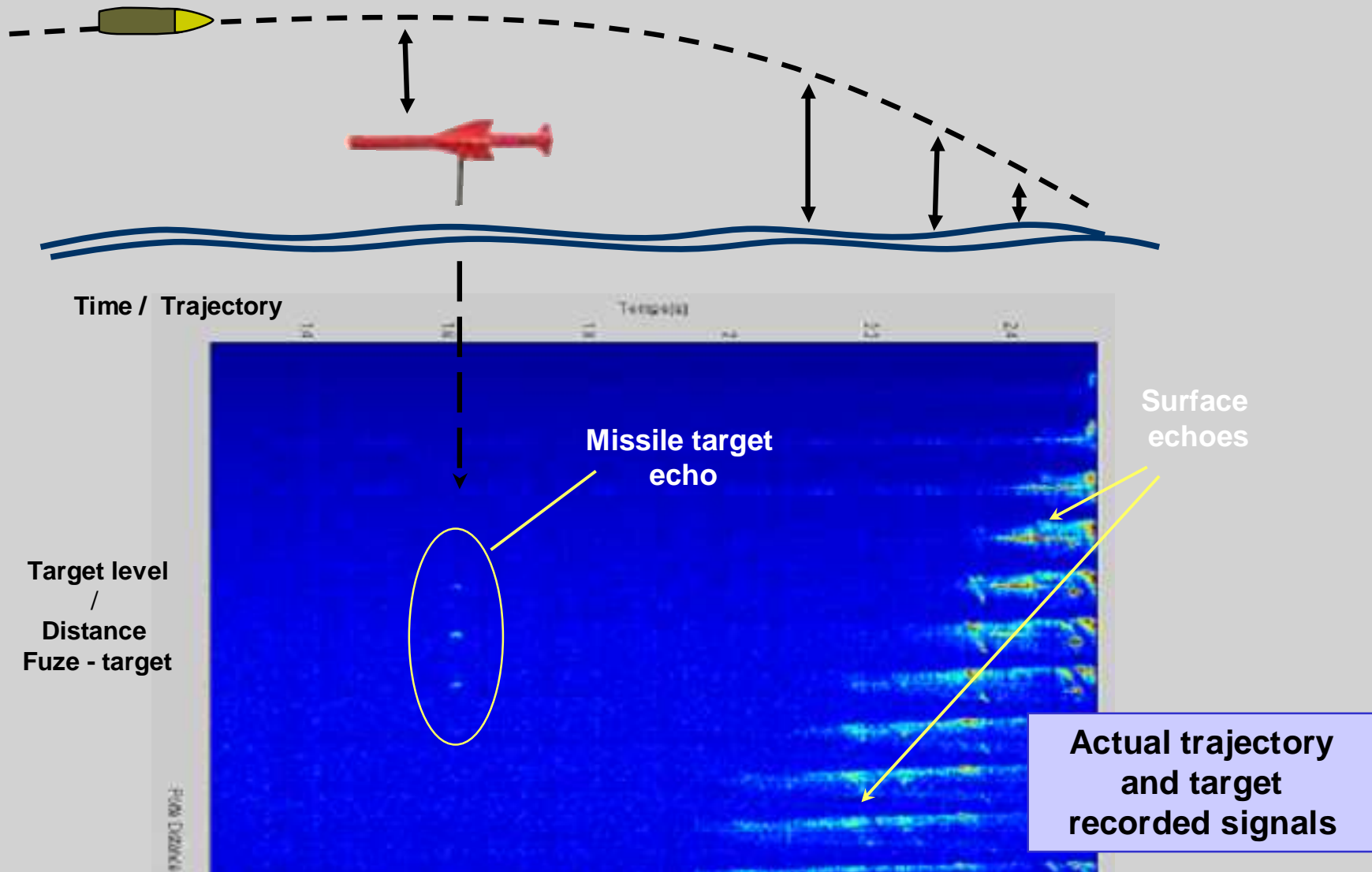


Signal Processing for Air-target detection

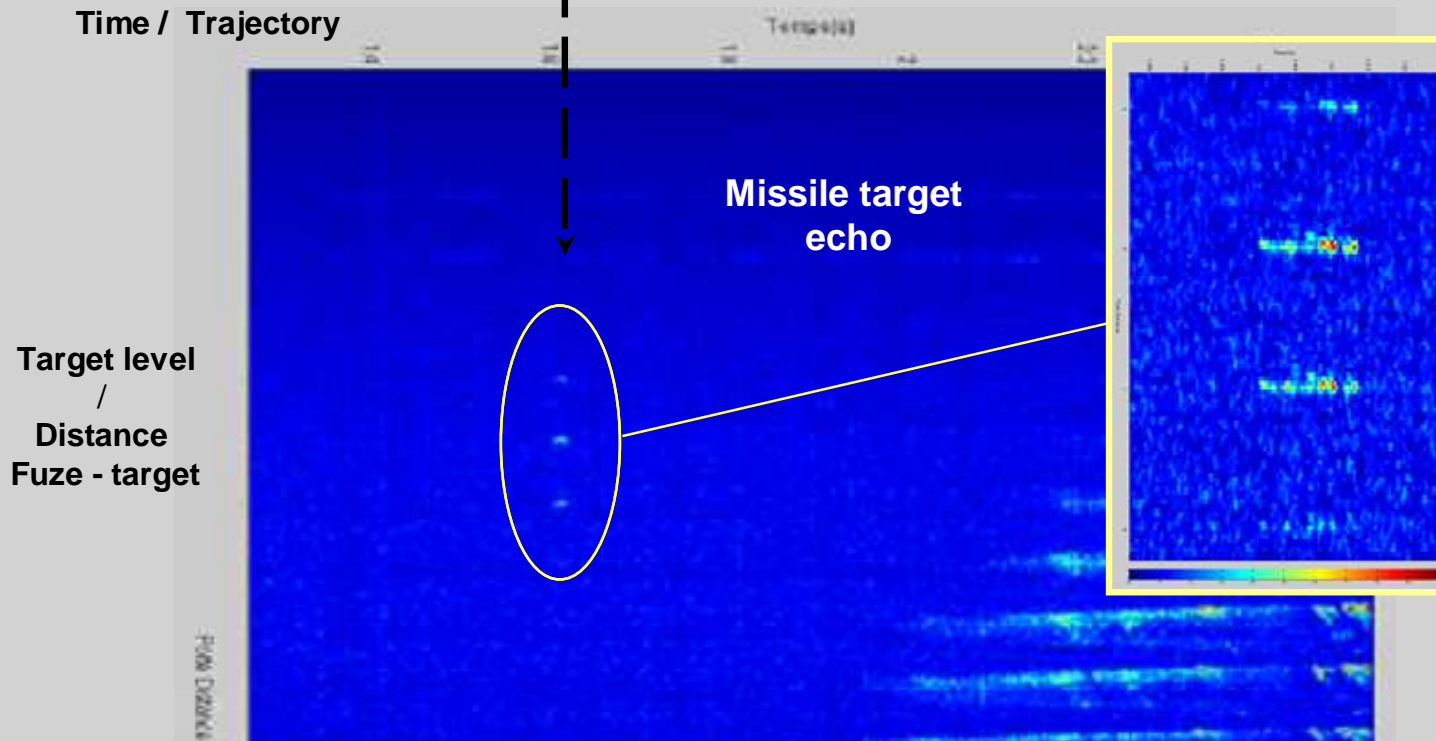
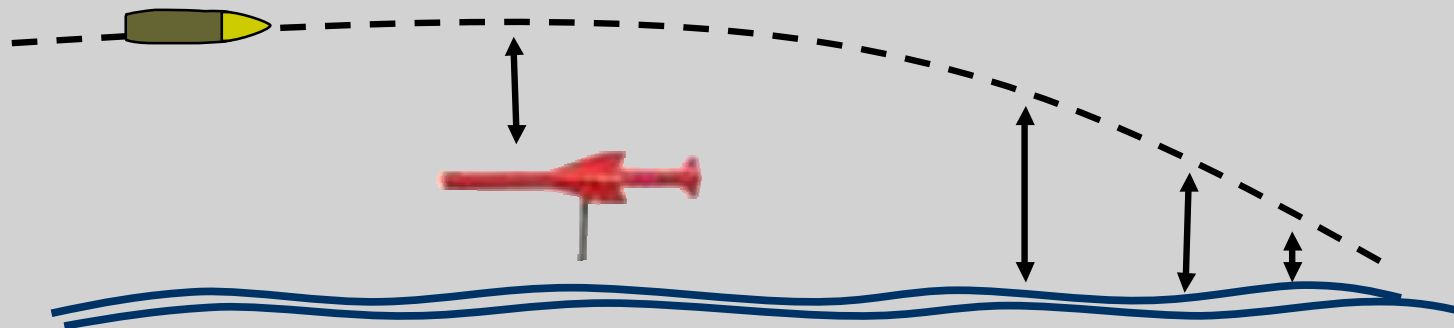
- Spectrum Analysis: Extraction of the target parameters
 - Target distance information
 - Speed - from the Doppler frequency shift
 - Radar cross section - from the signal level



Sea-Skimmer Detection



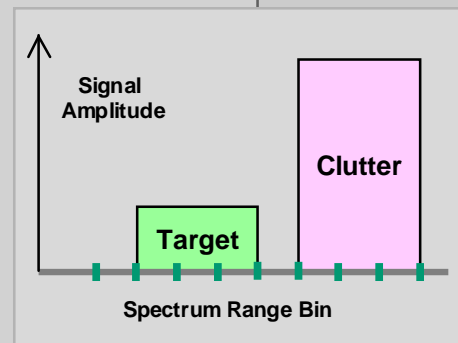
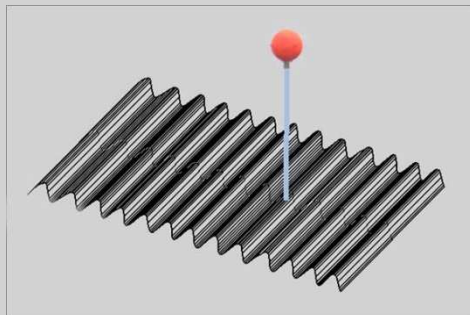
Sea-Skimmer Detection



Target / Clutter Discrimination

- The Signal Processing is able to extract the target echo from the sea clutter, even in the worst conditions with a very strong sea clutter

Signals recorded from actual firings on a very low altitude target (fixed) in presence of surface clutter, simulated by a large surface of wavy metal sheets

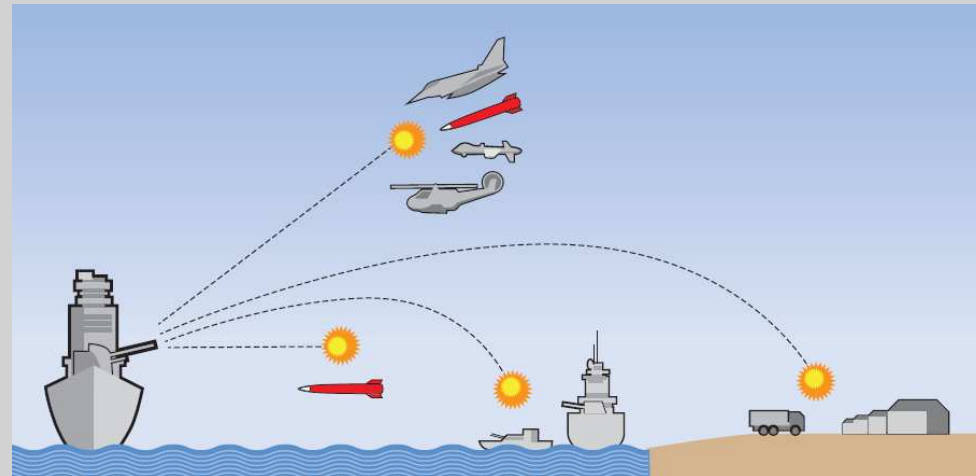


New Generation Naval Artillery Fuzes

FREMEN Fuzes



- Based on the new generation radar sensor fitted with smart signal processing
 - To provide the user with state-of-the-art multirole fuzes, specifically designed for the optimization of terminal effect against both air and surface targets
 - To achieve a broad range of missions
 - Air defence
 - Surface warfare
 - Naval Fire Support



- To succeed the previous generations of naval proximity / multirole fuzes, provided by JUNGHANS, in various calibers from 76mm to 127mm



FREMEN Fuzes – French Navy Contracts

- In early 2011 and 2012, JUNGHANS was awarded by the French Navy and MoD (DGA) 2 major contracts for the full development and production of new generation multirole fuzes



- **100mm** caliber: to replace the former generation fuze delivered in early 90's, with additional performances
 - for use with 100mm gun used on French Navy frigates



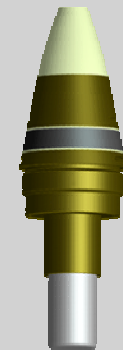
FREMEN 100



- **76mm** caliber: to fit new generation DIEHL Defence 76mm IM round (contract together for new round and fuze)
 - for use with the Oto Melara Super Rapido gun fitted on new French Navy FREMM and Horizon frigates



FREMEN 76



FREMEN Fuze – Main Features

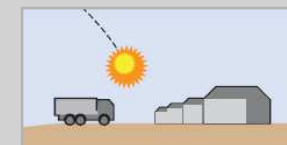
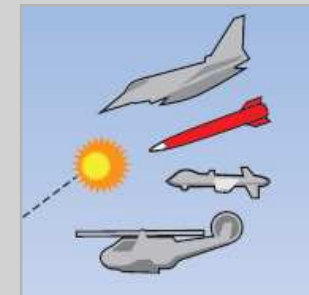
- Operating modes

- Proximity, against air or surface target
- Impact back-up
- Self-destruct mode, with possible inhibition
 - Manually, by external switch (100mm)
 - Automatically, through the gun setting device (76mm)

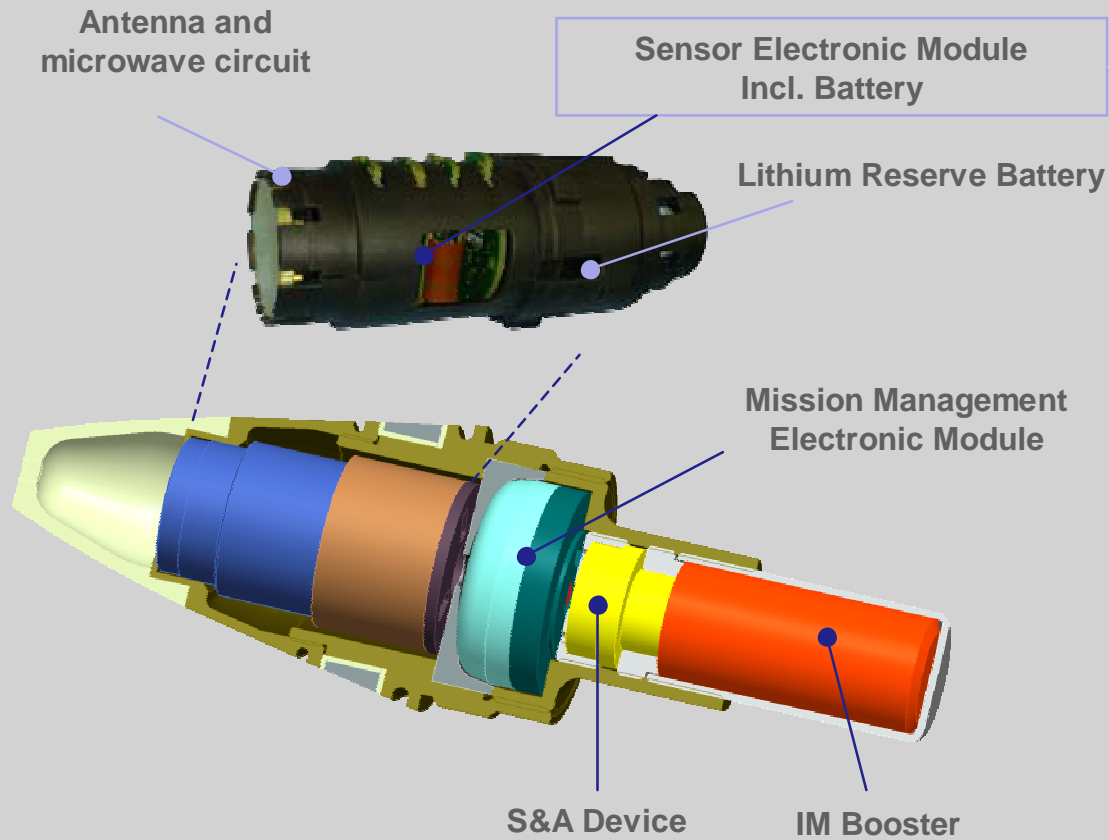


- Proximity mode

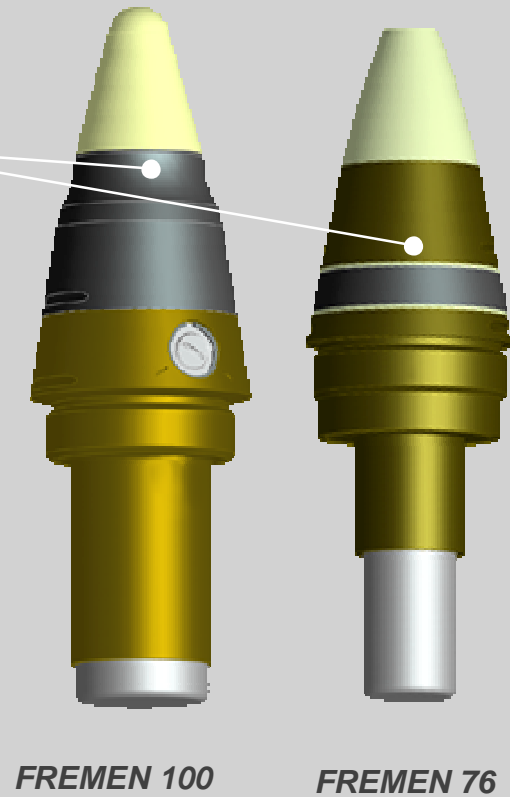
- The fuze autonomously selects either air-defence or surface fire mode, depending on whether the sensor identifies an air or surface target
- Air target
 - Optimized to defeat various types of targets: sea-skimming missiles, small targets such as drones, fixed or low speed targets such as helicopters or drones
 - Speed from 0 to mach 2
 - Low altitude (from 4m above the surface) or high altitude
- Surface target
 - Land or sea targets



FREMEN Fuze – Design Overview



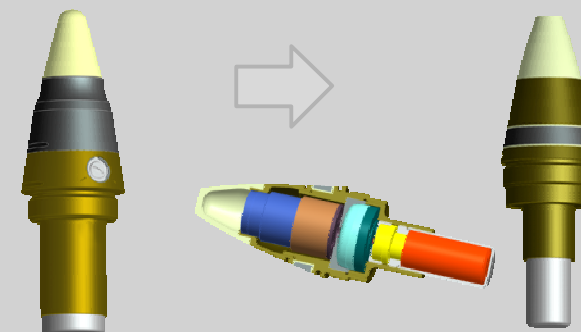
Modular Design



FREMEN Fuzes - Programme Status

- FREMEN 100mm and FREMEN 76mm
 - Contracts awarded in 2011
 - Definition Phase in progress
 - Sensor tests carried out on various types of targets, incl. small targets
 - FREMEN 76 development carried out at the same time as the FREMEN 100 development
 - LRIP delivery: 2014

FMCW sensor expected performance validated through live target firings (Fuzes specially equipped with embedded data recorders and telemetry)



Summary

- Up to now, FMCW + Digital Signal Processing techniques have not been implemented in Naval Artillery proximity fuzes (air defence)
 - This technology will considerably improve the proximity fuze efficiency and reliability, in particular by its capability to discern more easily the target signal from the sea clutter
 - JUNGHANS has successfully demonstrated the possibility to integrate this technology in new generation naval artillery proximity and multifunction fuzes

➔ With the new generation FREMEN fuzes, JUNGHANS will provide the Navy with unmatched operational capabilities to defeat air targets as well as surface targets, on land or sea.





Thank You

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