59TH ANNUAL FUZE CONFERENCE
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Fuzing Challenges for Guided Ammunition

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Introduction: Finmeccanica Guided Ammunition

DART (Driven Ammunition Reduced Time-of-flight)

Fired by Naval 76/62 guns

VULCANO ammunition family

Guided and unguided versions for:

- 76mm (Naval gun)
- 127mm (Naval gun)
- 155mm (Land Artillery)

Multiple configurations with:

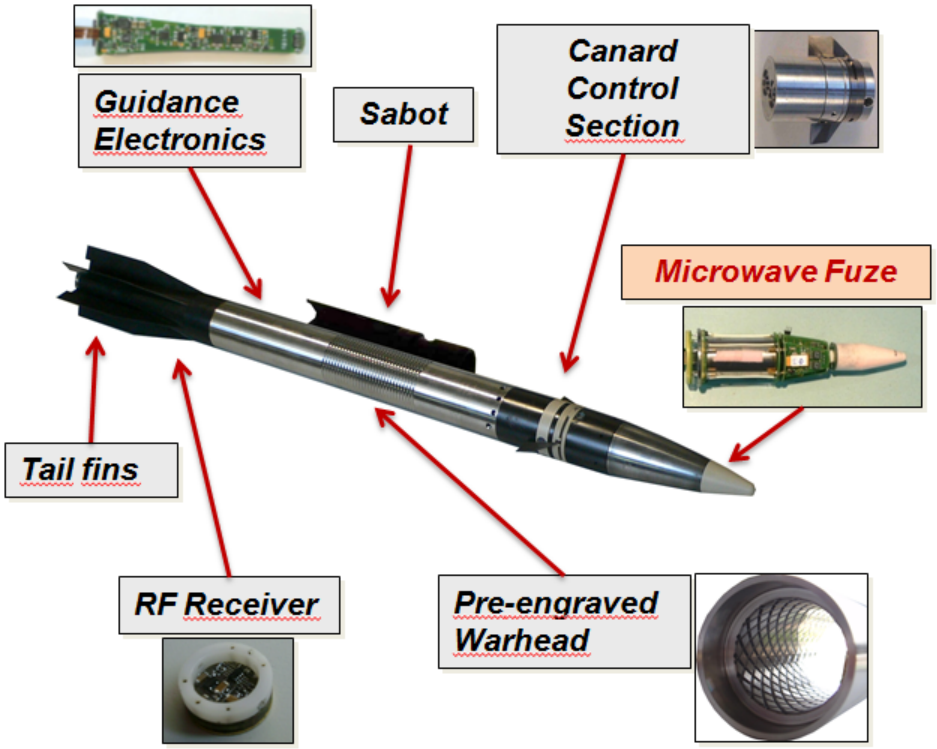
- ✓ RF fuze
- ✓ IR seeker
- ✓ SAL seeker

Introduction: Finmeccanica Guided Ammunition

DART ammunition

Naval inner layer defence system against high manoeuvring air and surface targets

- ✓ Sub-caliber
- ✓ RF beam-guided in Line of Sight
- ✓ Free rolling, fin stabilized projectile
- ✓ CANARD section roll and pitch controlled
- ✓ Very high manoeuvrability
- ✓ RF proximity fuze
- ✓ Fired from 76/62 guns with STRALES guidance system



Introduction: Finmeccanica Guided Ammunition

Vulcano ammunition family

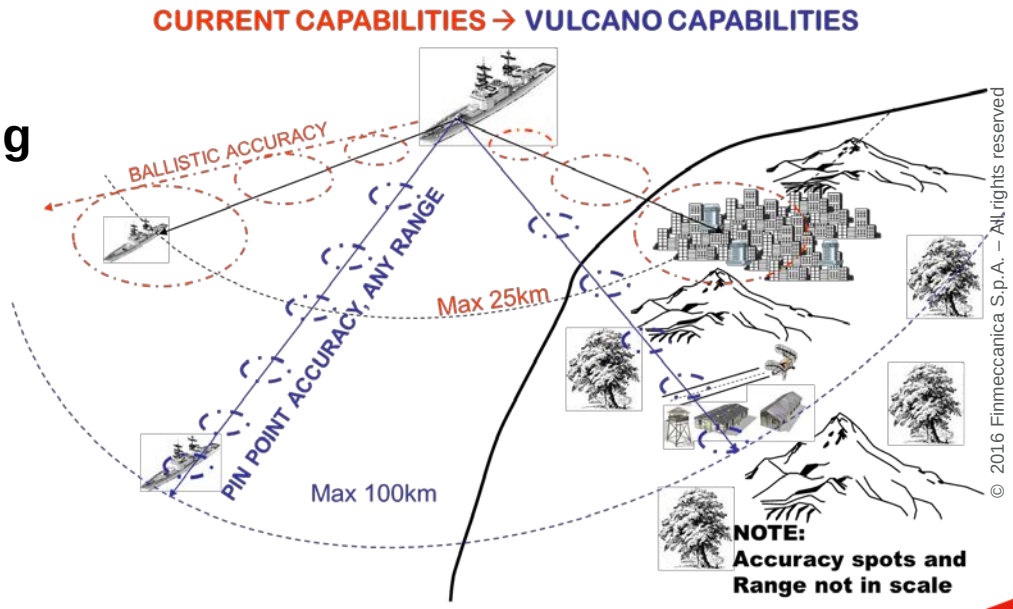
Vulcano BER: Ballistic, Extended Range

Vulcano GLR: Guided, Long Range

- GPS/IMU configuration with RF fuze
- Configuration with IR seeker
- Configuration with SAL seeker

Different possible roles, depending on calibre and configuration:

- Long range fire support
- Anti-ship
- Anti-air



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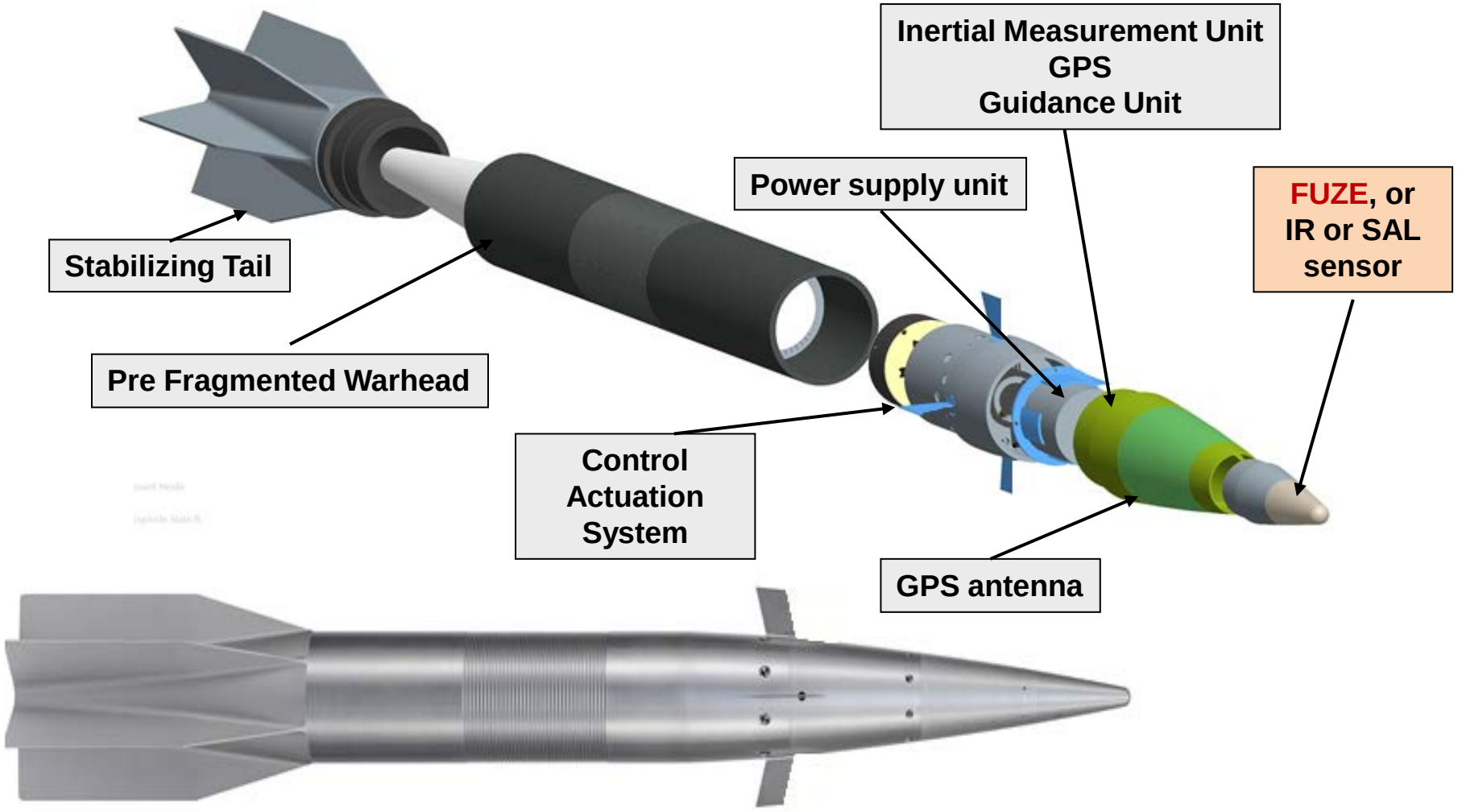
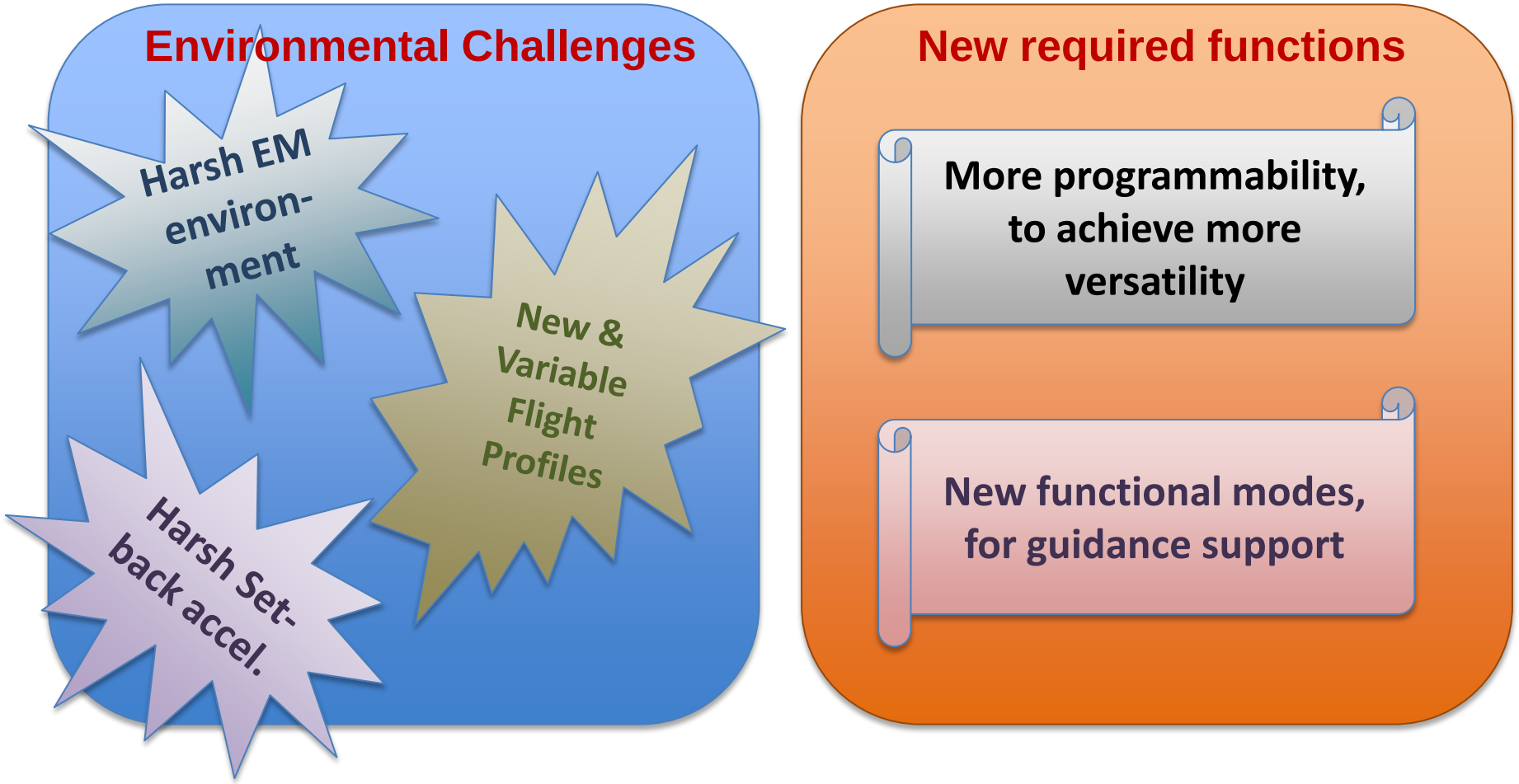
Introduction: Finmeccanica Guided Ammunition

Vulcano Guided Long Range subsystems



Fuze Design Challenges for GUIDED SUB-CALIBRE ammunitions



New Environmental Challenges

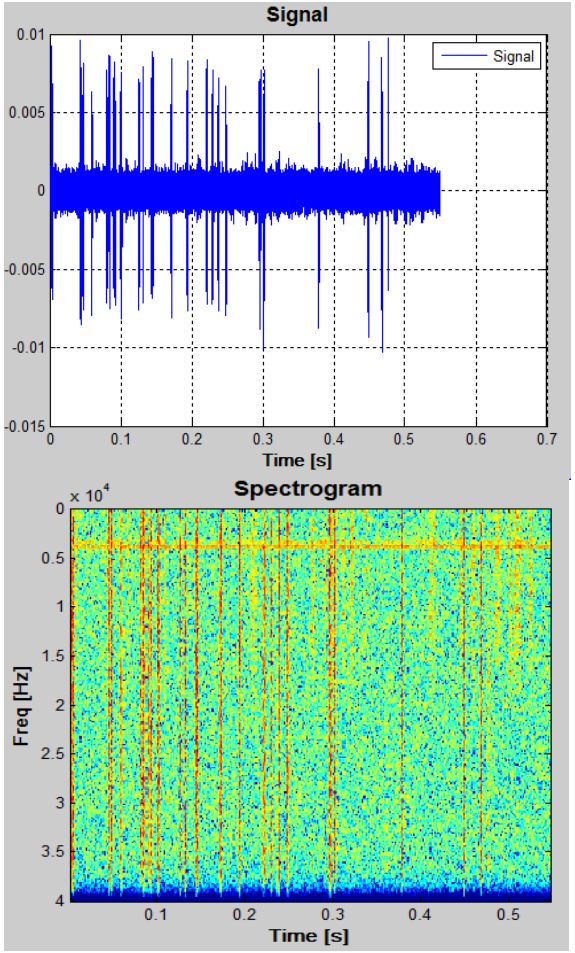
Harsh ElectroMagnetic (EM) environment – Issues

“Standard” disturbance sources:

- Own Radar systems (now also including RF guidance systems)
- Enemy Radar systems
- Intentional Jammers

New internal disturbance sources:

- Electric disturbance from other electronic circuits
- Disturbance from electric motors (via PWM control signals, and peak current absorptions)
- Disturbance from the actual movements of guidance fins, located near the Doppler sensor



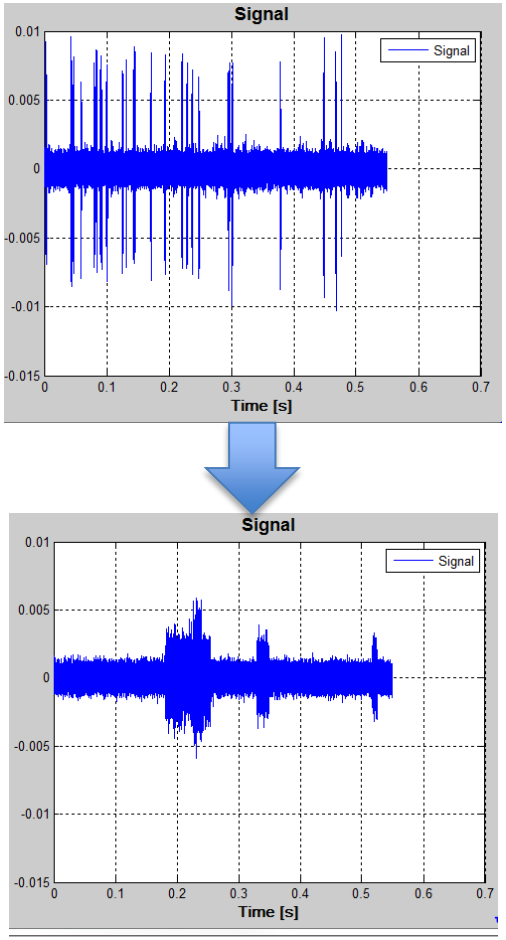
New Environmental Challenges

Harsh ElectroMagnetic (EM) environment – HW solution approach

Hardware solutions for the elimination, or the reduction, of both the electrical and mechanical disturbance:

- ✓ ***Selection of electronic components introducing less disturbance in the circuitry*** (typical disturbing components to be chosen with care are: microprocessors, clock generators, digital communication drivers, PWM signals for electric motors…)
- ✓ ***Use of electronic filters*** to reduce the disturbance toward the RF sensor
- ✓ ***Electric isolation of guidance fins***

However, some disturbance is always present…



New Environmental Challenges

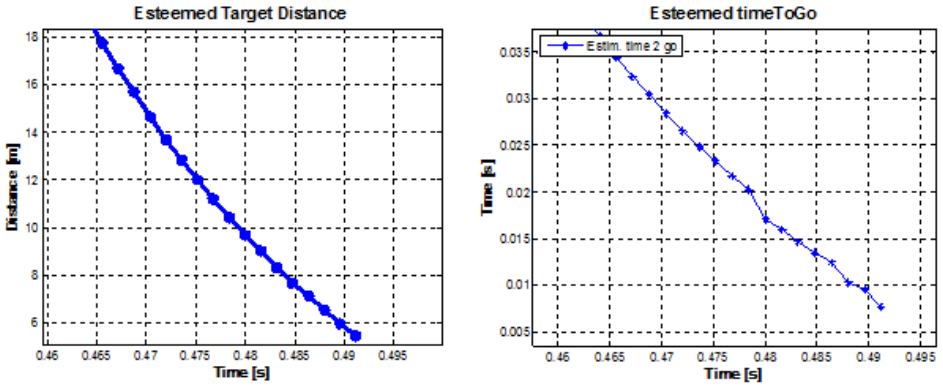
Harsh ElectroMagnetic (EM) environment – SW solution approach

Necessity of **new algorithm features**, in order to:

- **Recognising** in flight all the described disturbance
- **Discriminating** the disturbance from the real target Doppler or sea Clutter signals
- **Maintaining good reliability** in the presence of a disturbed EM environment

A good way to achieve this goal is to use of a **Frequency Modulation** of the RF signal, enabling:

- More robust target detection
- Target distance measurement
- Continuous computation of "time-to-go" before intercept



New Environmental Challenges

Increase of set-back acceleration

Sub-calibre projectiles feature higher muzzle velocity → Higher set-back acceleration!

DART set-back up to 40,000g!

All the fuze components, new or already used in old full calibre fuzes, have been tested with **gun hardening** trials (laboratory and firing tests)

NOTE: in-barrel lateral accelerations are also greater than for full calibre!

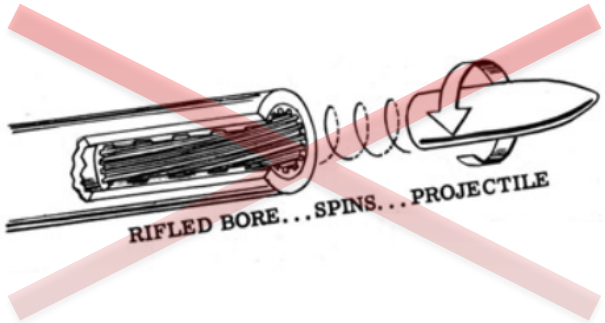
New Environmental Challenges

New profiles of flight stimuli

Guided Sub-Calibre ammunition Vs Ballistic Full Calibre ammunition:

- Different spin (typically lower and variable)
- Different drag (typically lower)
- Different lateral acceleration (in barrel and in flight)

Traditionally conceived Safety and Arming Unit used in Full Calibre projectiles are not suitable!



Necessity of S&A based on different flight stimuli, for example:

- ✓ **Detection of low spin flight profiles using electronic sensors**
- ✓ **Gas pressures in barrel or aerodynamic pressures in flight**

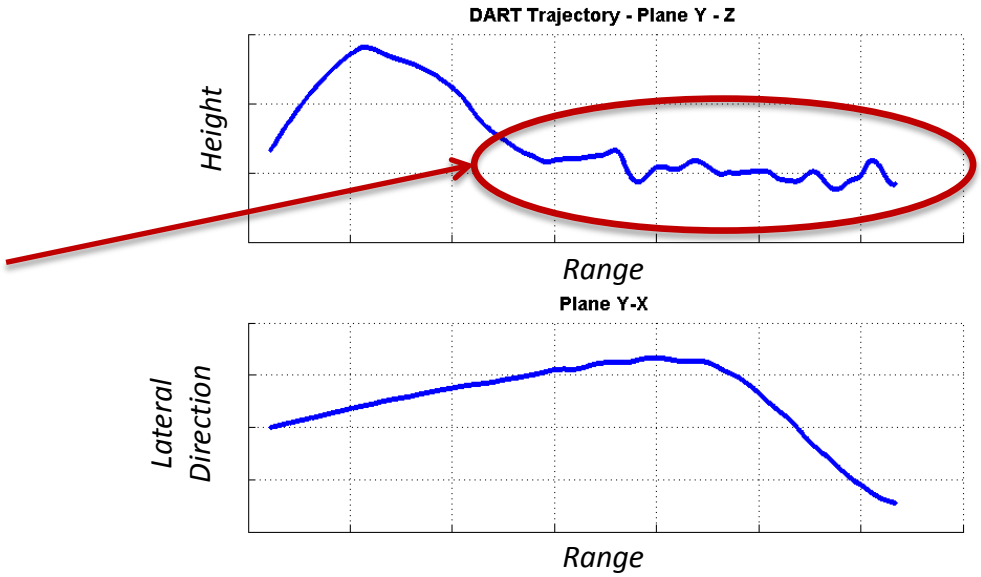
New Environmental Challenges

Variable flight profiles

Flight profiles vary depending on the mission.

Vulcano ammunition missions are planned before the launch; conversely, DART ammunition missions can change unpredictably during flight, due to the manoeuvrability of the target!

A very particular case study is DART fired against a surface target or sea-skimming missile: in this case the whole guided mission takes place at a **few meters above sea level!**

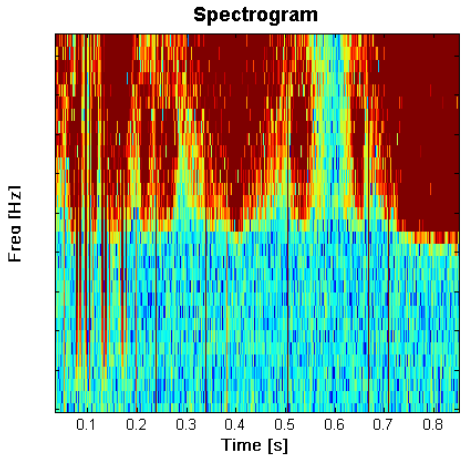


New Environmental Challenges

Influence of low altitude flight profiles on RF fuze

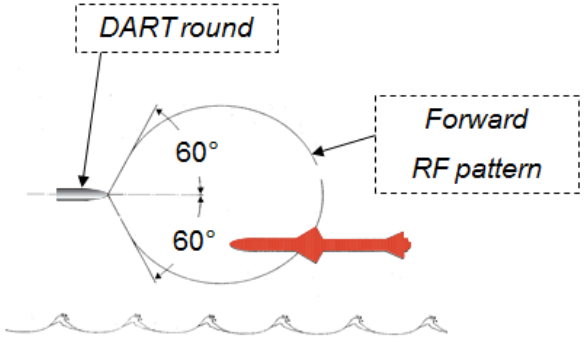
Low altitude missions above sea level

- Clutter always present during proximity mission
- Local sea state variability produces sudden clutter changes



Necessity of:

- ✓ **Forward-looking RF lobes,** to reduce clutter influence
- ✓ **Smart algorithm** to discriminate sudden clutter changes from real target Doppler signal



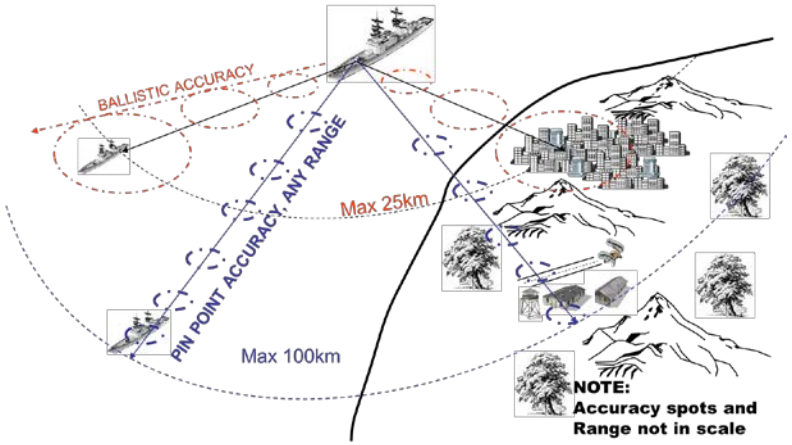
New Functions required for guided projectiles

Requirements for more programmable features

Guided ammunitions are **more precise** than ballistic ammunitions → **"One shot = One hit" is possible!**

…

But they are also **more expensive**! → **"One hit = One kill" is a reasonable requirement**



New requirements for the fuze:

- **More Reliability**
- **More Programmability, to increase the versatility of the same ammunition against different targets!**

New Functions required for guided projectiles

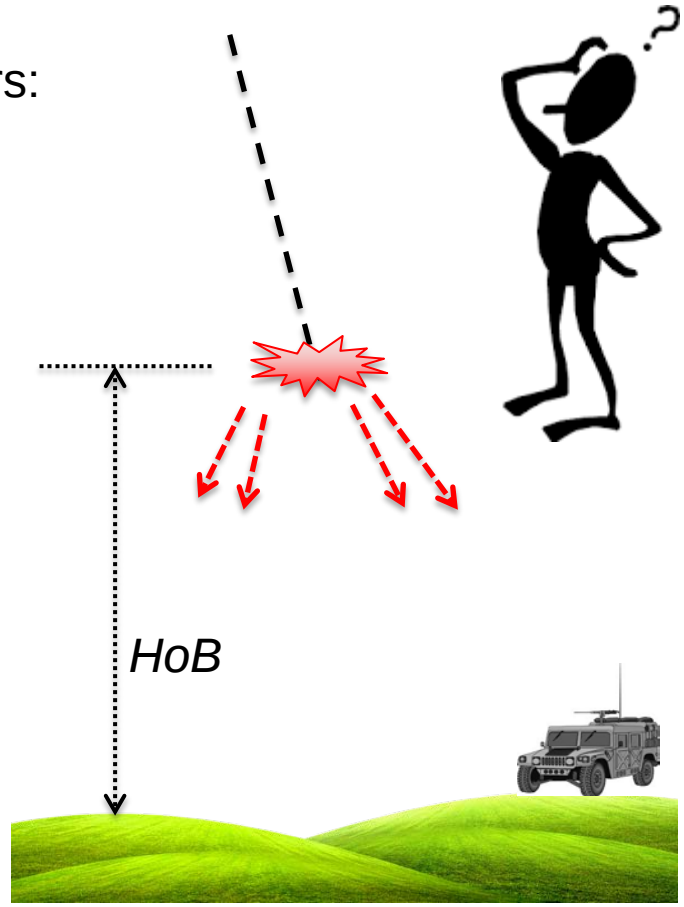
Programmability of the Height of Burst

Optimal height of burst depends on many factors:

- ✓ Target type (Vehicles, Troops, Buildings…)
- ✓ Fragmentation pattern
- ✓ Terminal projectile velocity

<u>A fuze with a fixed height of burst is not always the right solution!</u>

Vulcano ammunition customers required programmability of the Height of Burst before the launch, in order to optimize lethality against different targets

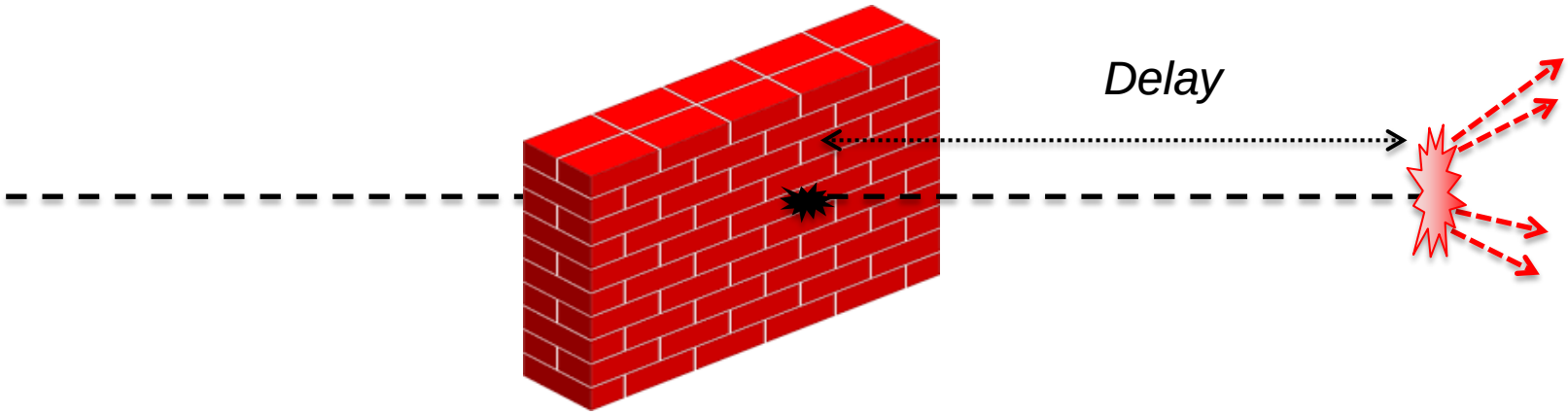


New Functions required for guided projectiles

Programmability of the Explosion Delay after Impact

Referring to the Delayed Point Detonation function,
the optimal delay time depends on following factors:

- Target type
- Projectile residual velocity

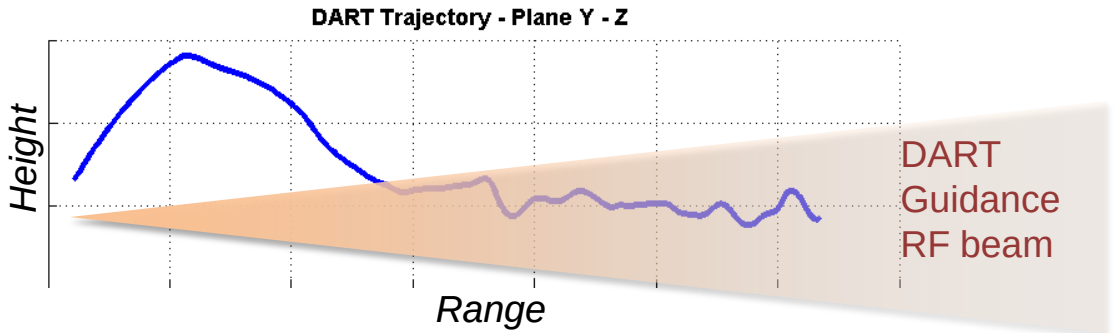


Vulcano ammunition customers also required the programmability of the delay time after impact, in order to optimize lethality against different targets

New Functions required for guided projectiles

DART Altimetric Function for Guidance Support

For DART ammunition against surface targets or sea-skimming missiles:

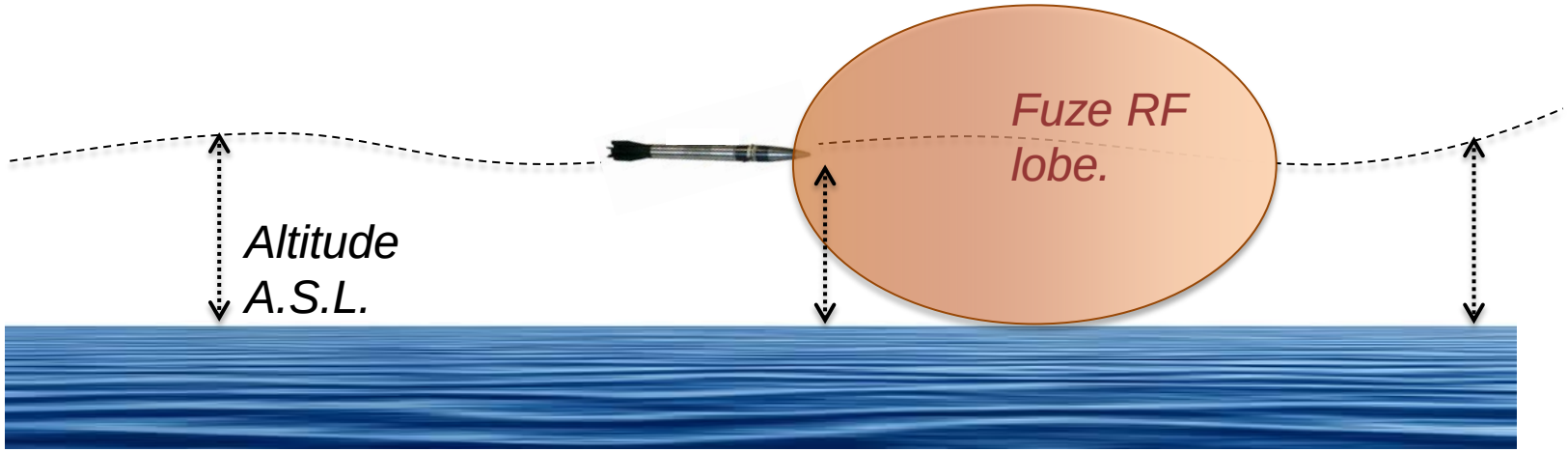


Low altitude of the target → Low altitude of DART flight → Possibility of **multipath** disturbance on guidance beam → Possible **projectile precision loss,** in vertical direction

Help from the FUZE subsystem is required!

New Functions required for guided projectiles

DART Altimetric Function for Guidance Support



Sea clutter, which, for the proximity algorithm, is only a disturbance, can be also a **resource**… During the whole flight,

the proximity fuze can also be used as an altimetric sensor!

The measured altitude can be used by the guidance unit, to increase projectile precision in the vertical direction.

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