Pyro-MEMS
Technological breakthrough in fuze domain

Fuze Conference 2009

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Lake Buena Vista, FL

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2. Design & Demonstration of MEMS SAU
3. Design & Demonstration of 25mm Airburst ammunition Mk I
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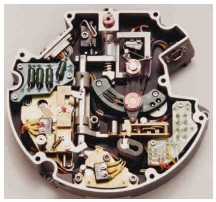
1. NEXTER Munitions Fuze activities

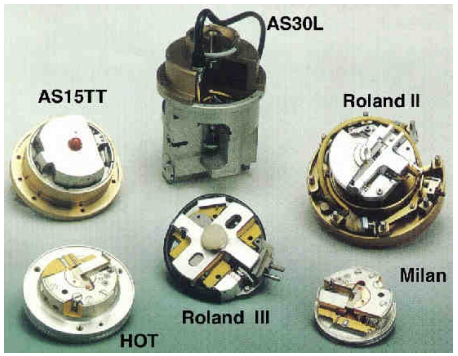
NMu: Fuzing System manufacturer

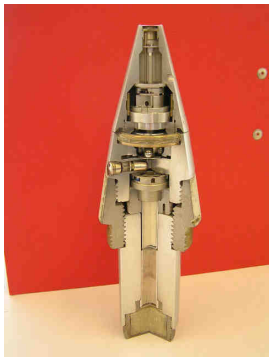
Products: Fuzing system & SAU for missile, tank ammunition (120, 100, 90 mm caliber), naval artillery (100mm caliber) and medium caliber (40, 30 and 25 mm caliber).



Strengthes:

- **Pyrotechnical components manufacturer (primary & secondary)**
- **Own proving ground**
- **The complete munition designer**

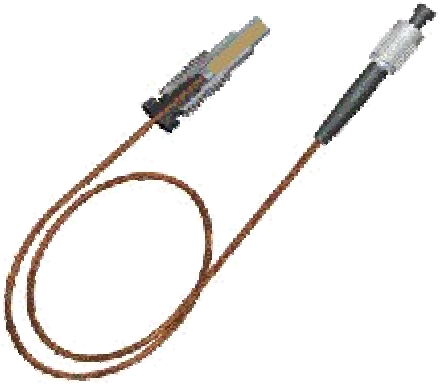


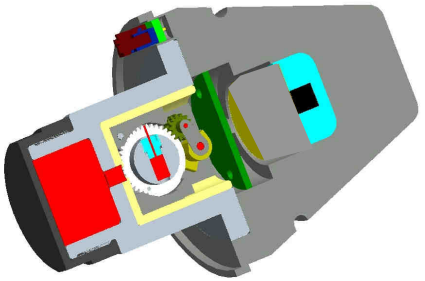


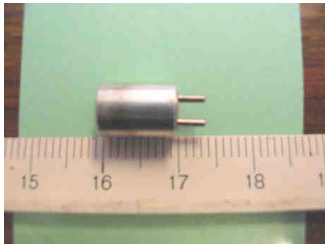
NMu: Fuzing System designer

Applications:

- Airbursting ammunition
- Opto-Pyro
- LEEFI
- ...







Strengthes:

- Modelisation
- Data recorder
- Own proving ground (static, pyrotechnics, dynamic)
- Same group than weapon system designer (NEXTER Systems)

1) Design & Demonstration of MEMS SAU

Contract 03.04.078 – Demonstration of miniaturized SAU

1) MEMS SAU

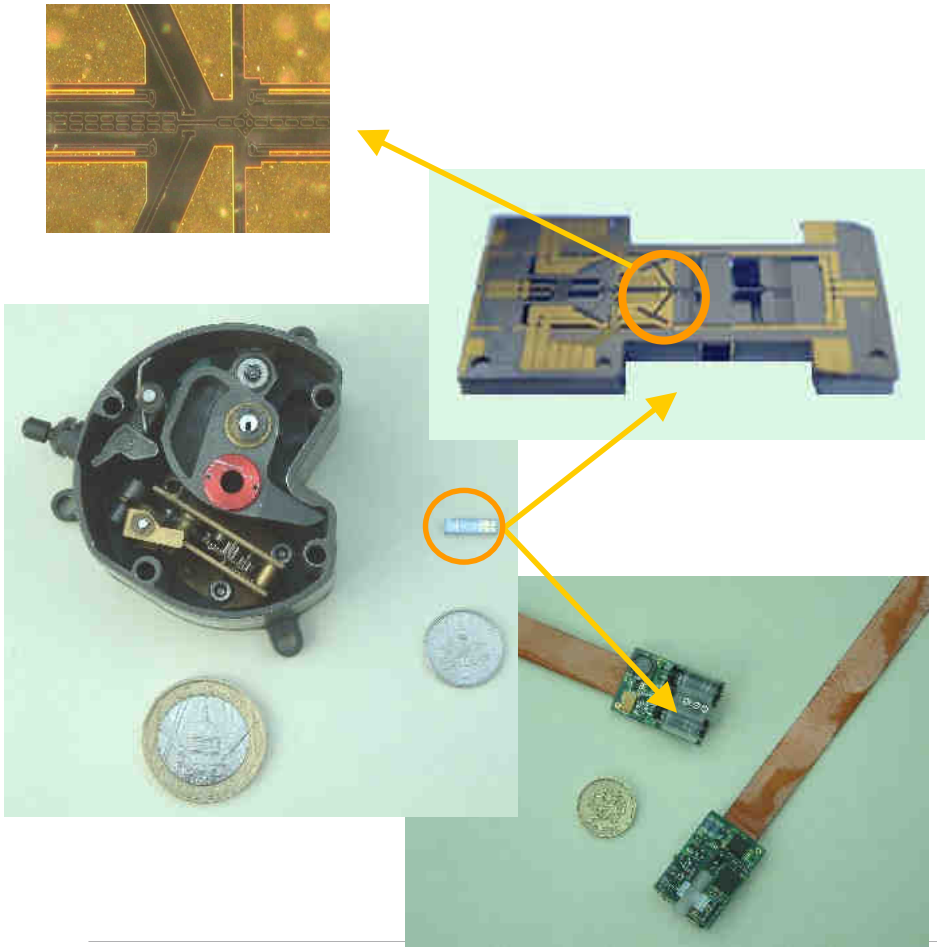
Technology MEMS

Pyrotechnical interruption

Miniaturized Electronic driver

STANAG 4187 compliance

Micropyrotechnics, Synergy of mechanics, electronics & pyrotechni



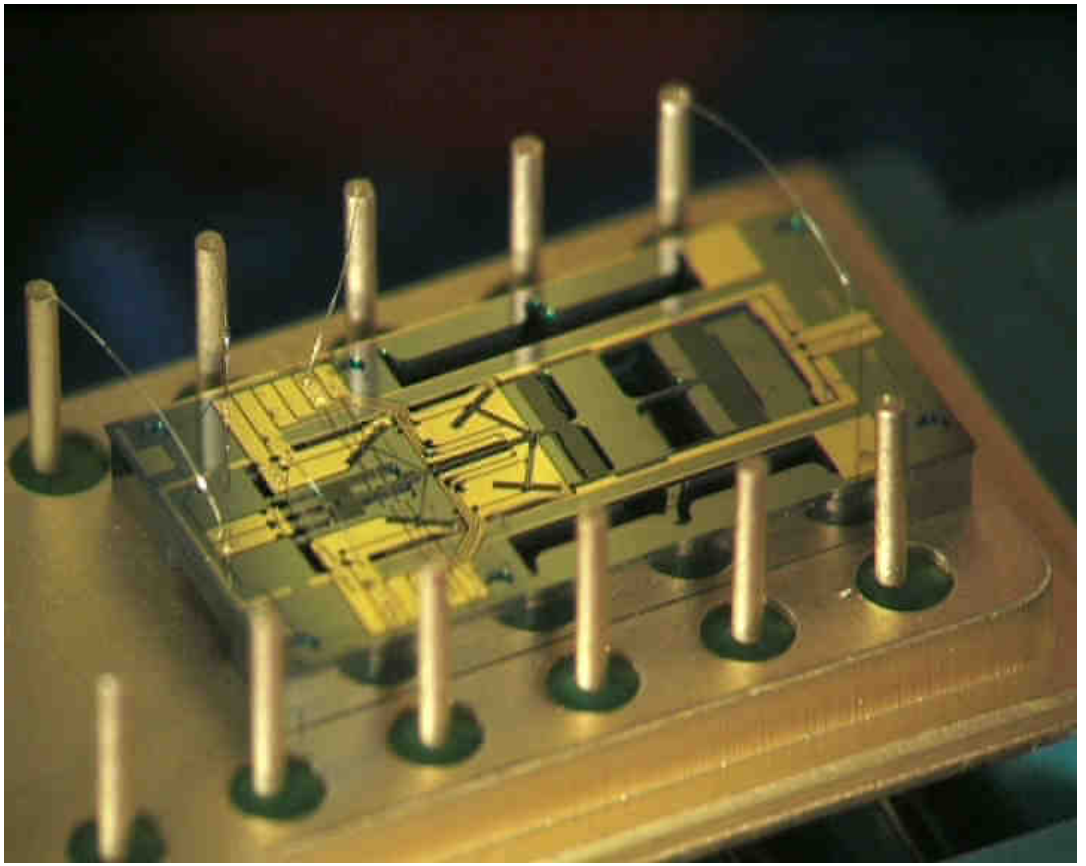
The Step Forward

03/2007 – delivery of 10 µ-SAU

Requirement

- **Pyrotechnical safety managed by electronically controlled MEMS**
- **Volume less than 2 cm^3**
- **In accordance with STANAG 4187 (last edition)**
- **Ignition of EIDS**
- **Low cost**
- **Generic SAU**

Arming ability and reversibility

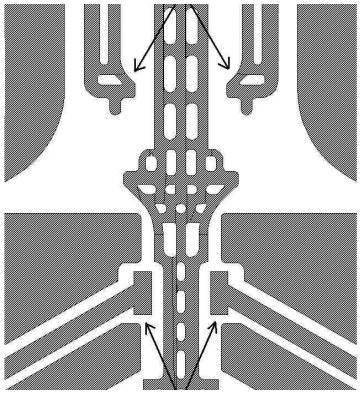


MEMS design according to STANAG 4187 requirements

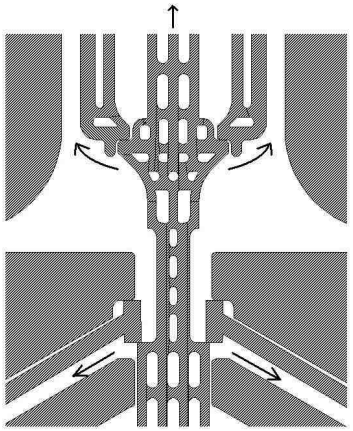
ARMED

SAFE

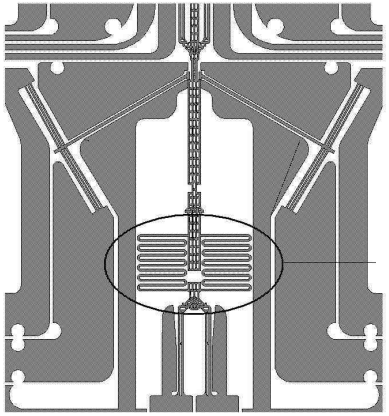
1st Safety lock

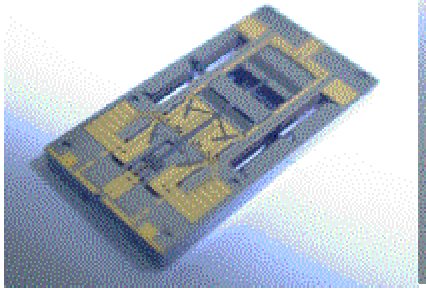


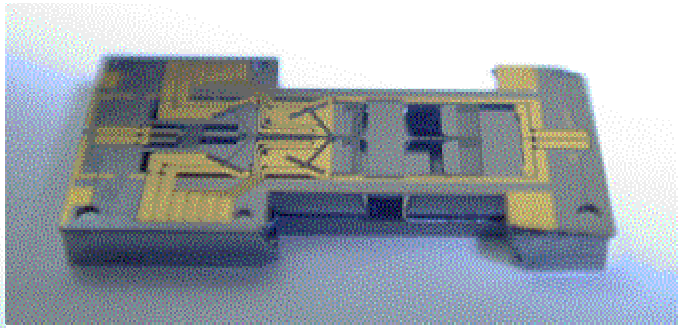
Arming displacement



2nd Safety lock

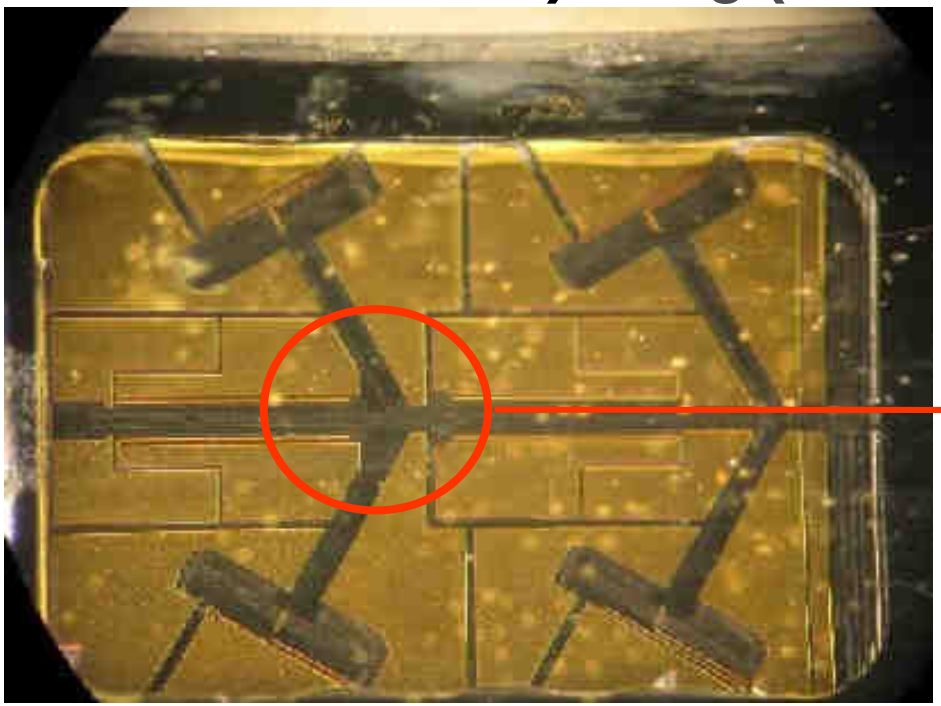


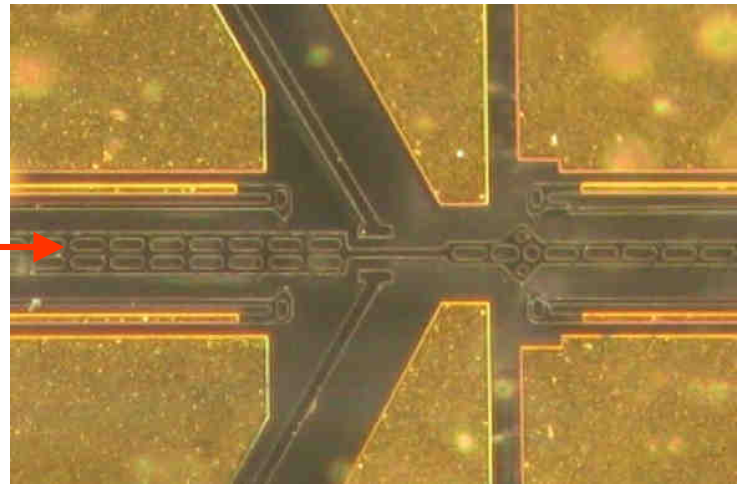




Environnemental conditions :

- **120mm ammunition Polynege (Laser guided tank ammunition) firing (~10 000 g)**





View of the actuators after firing

1) MEMS SAU

Technology MEMS

Pyrotechnical interruption

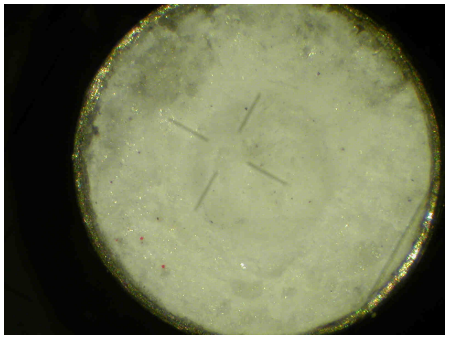
Miniaturized Electronic driver

STANAG 4187 compliance

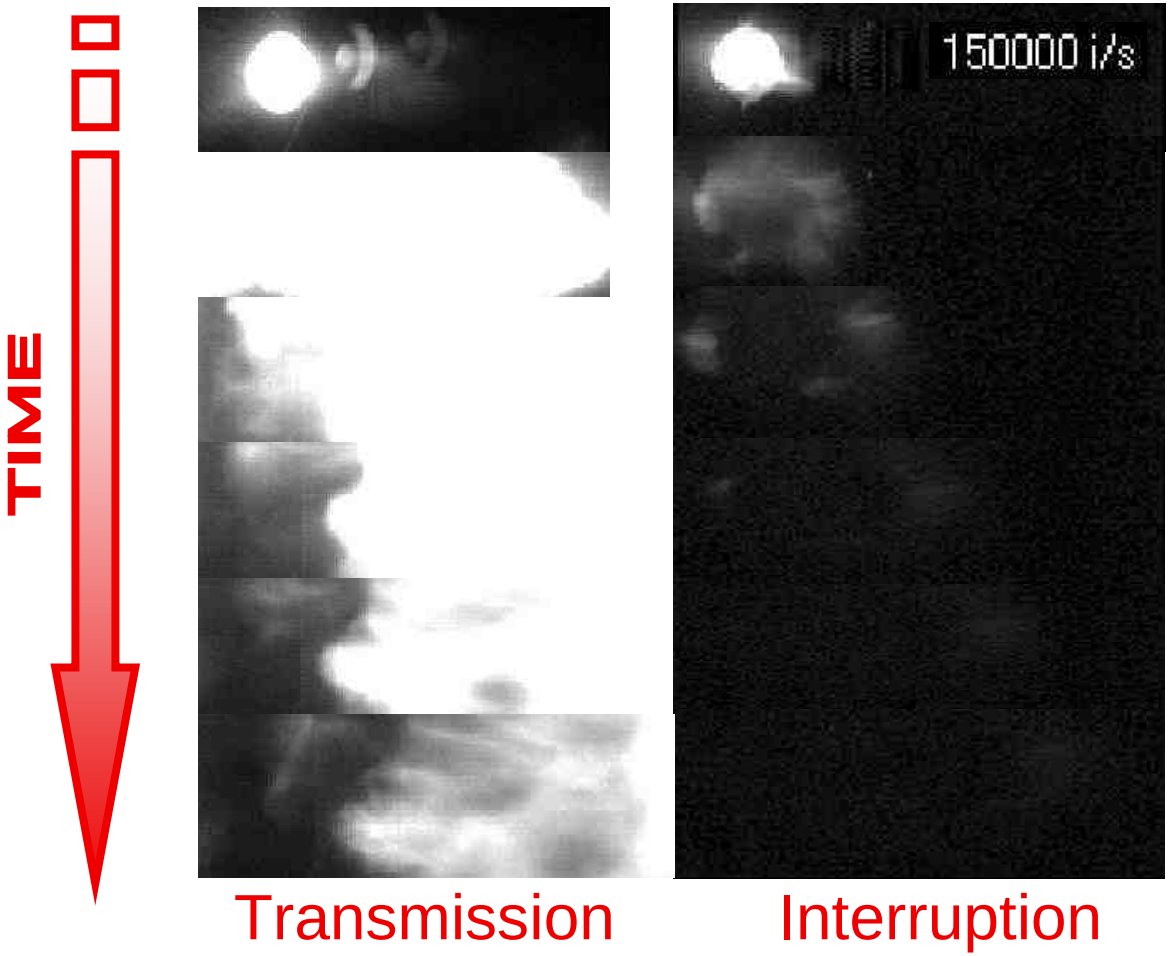
Reliability and safety perfromances obtained by hardened tests (GTPS)

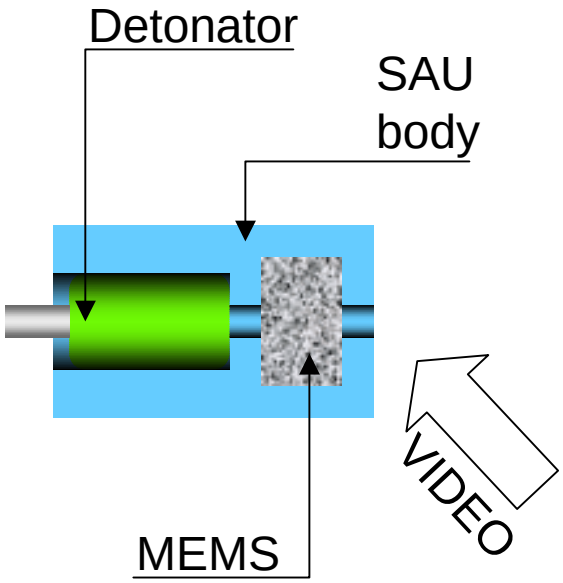
- **Reliability : 0,999 with 75 % confidence level**
- **Safety : 0,9999995 with 90 % confidence level**

- **Interruption test on PETN booster**



Pyrotechnical tests





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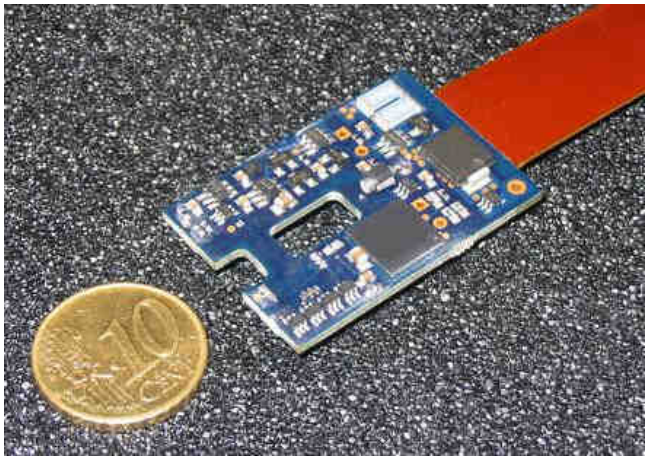
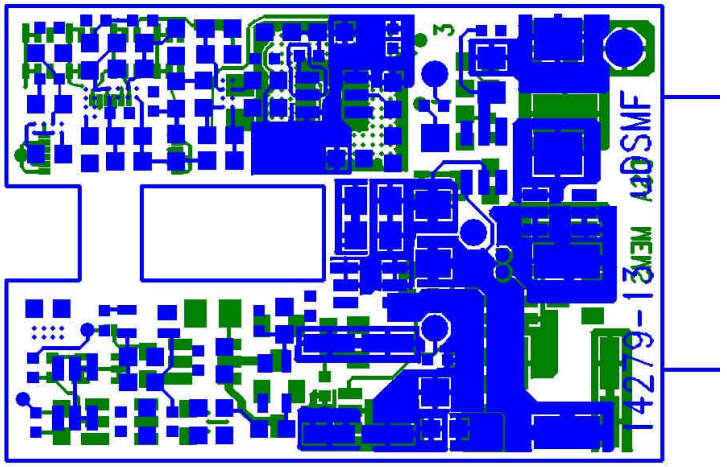
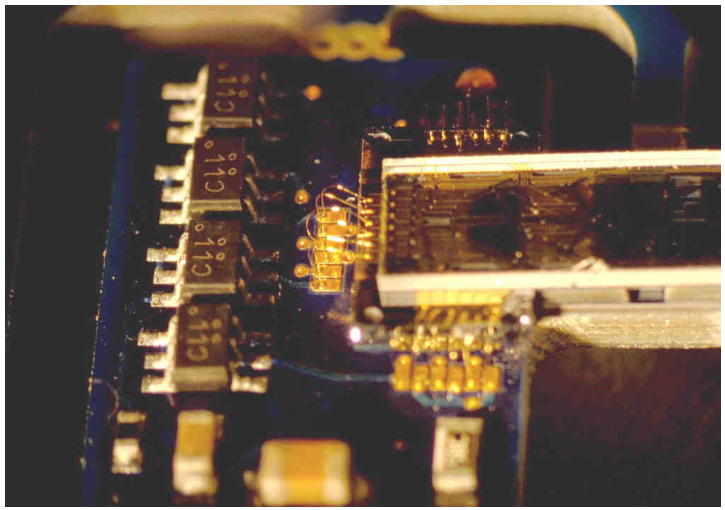


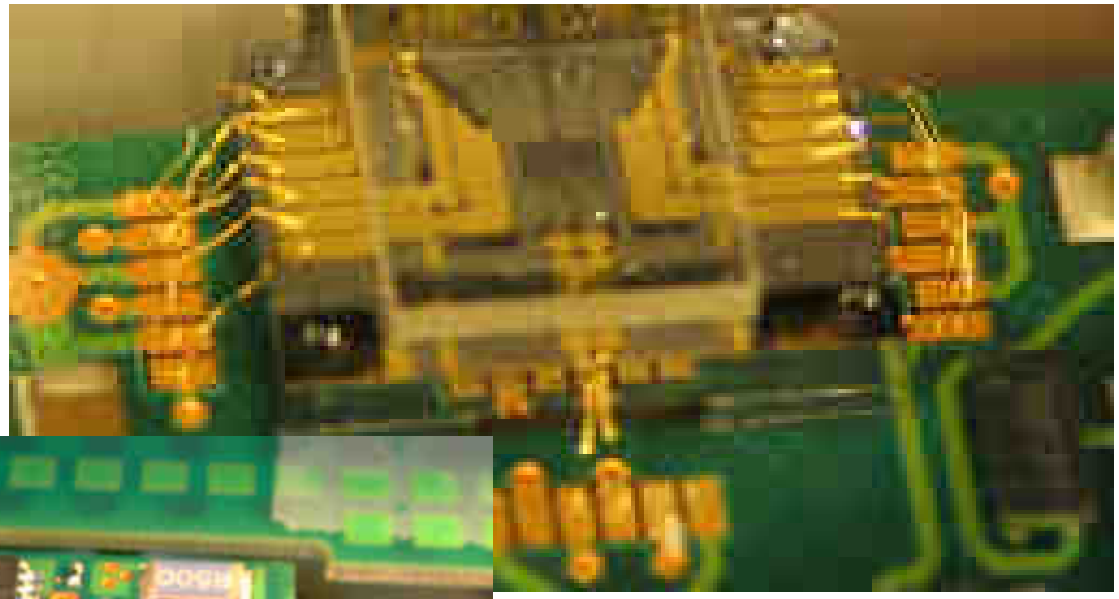


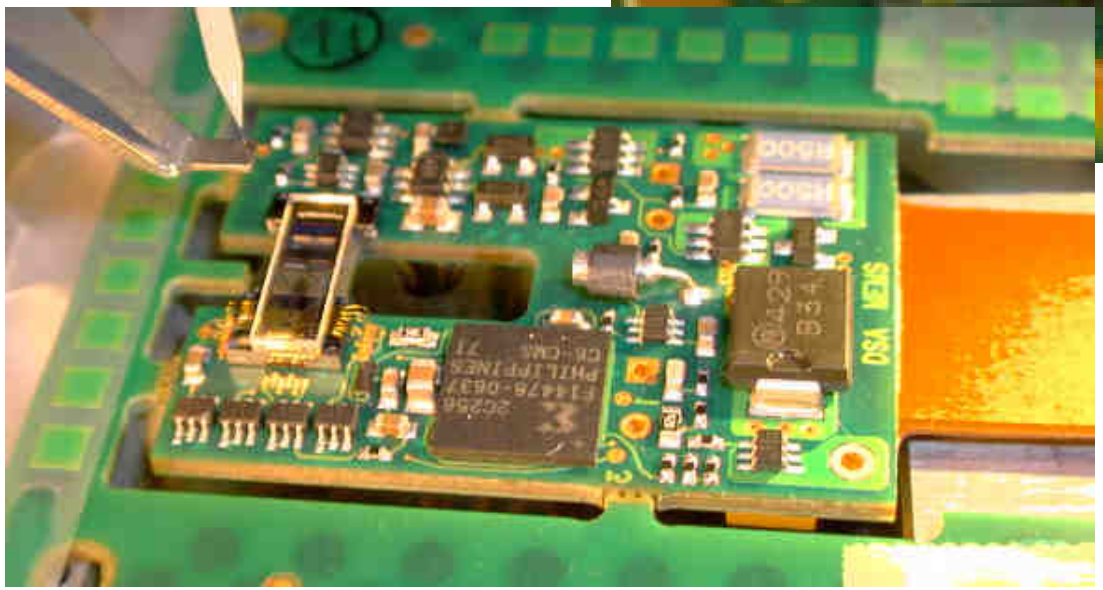
High density PCB

- **8 layers**
- **High density of parts**
- **« In Pad » vias**
- **In board vias**
- **« Flex » PCB**



Integration





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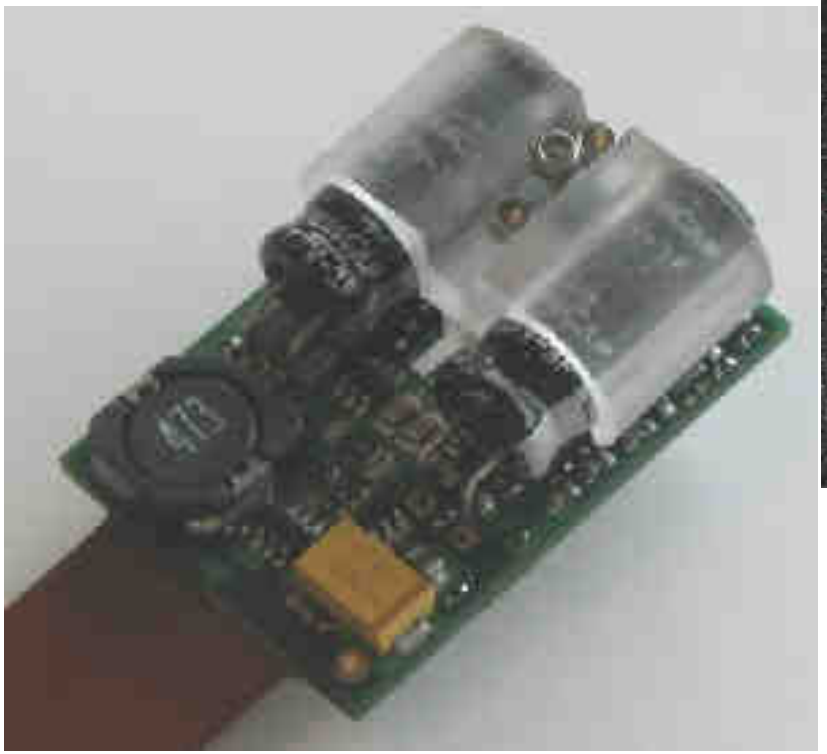
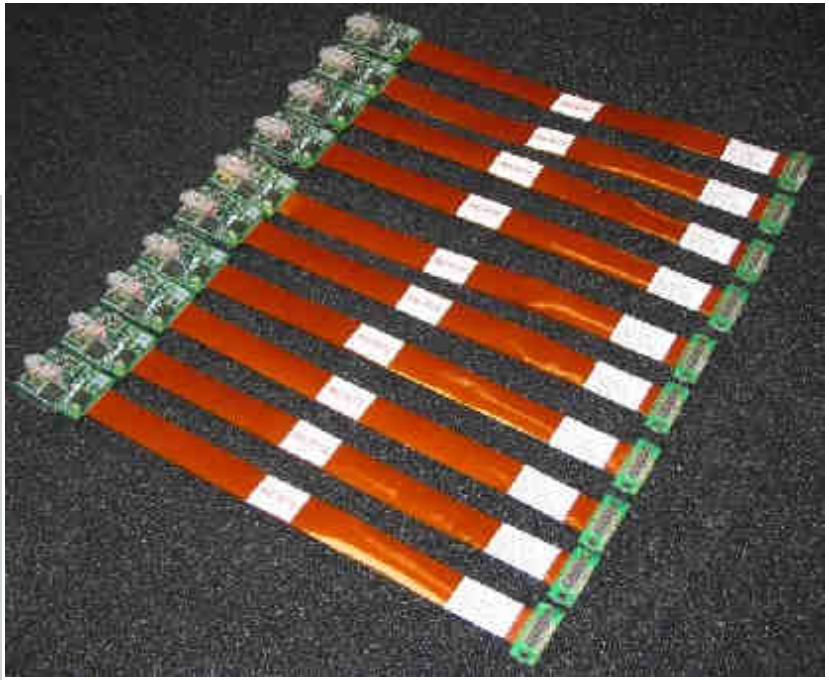




1) MEMS SAU

Technology MEMS

Pyrotechnical interruption

Miniaturized Electronic driver

STANAG 4187 compliance

Compliance with STANAG 4187

- ✓ **Two independant safety devices [Exg 6.a).1] : OK**
- ✓ **Two independant orders to authorize arming sequence [Exg 6.a).1] : OK**
- ✓ **Physical shutter between detonator and booster [Exg 8.a).1] : OK**
- ✓ **Explosive assessment and approval : COTS pyrotechnical devices OK [Exg 7.a)] : OK**
- ✓ **Efficiency of the interruption of the micro scale fire train : OK [Exg 8.a).2] : OK**
- ✓ **Non-armed guaranty during assembly and installation : [Exg 12.a)] : electrical information about shutter status is available**

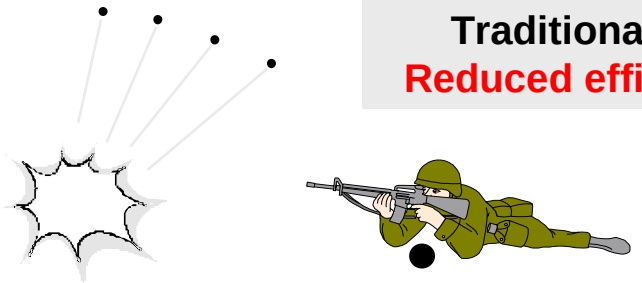
1. Design & Demonstration of 25mm Airburst ammunition-Mk I

Contract n°05.50.208 – Improvements of medium calibre ammunition

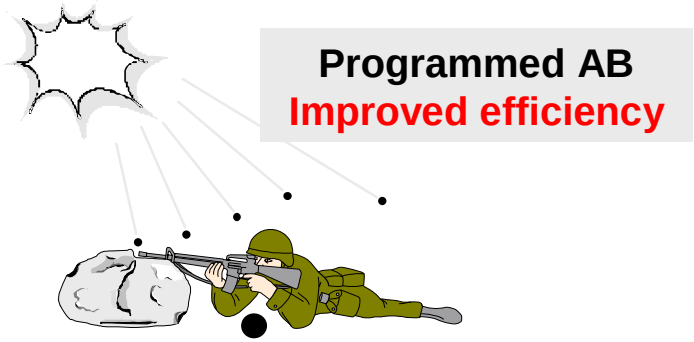
Demonstrator for a programmable air bursting 25 mm round

Aims of the study

- Airburst has to be initiated above the target with an accuracy of 1 m at 1000 m
- Airburst mode shall be compliant with the maximal range of the 25, 30 and 40 mm weapons
- Impact mode available
- Compliance with STANAG 4187
- Airburst Fuze Programming Unit shall be able to equip existing weapons systems (retrofit)

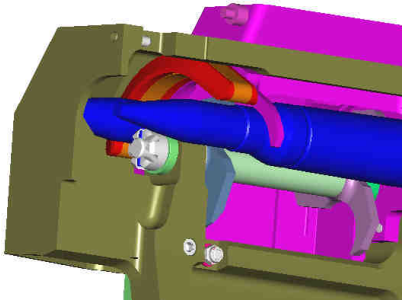


Traditional PD
Reduced efficiency

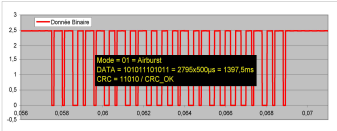


Programmed AB
Improved efficiency

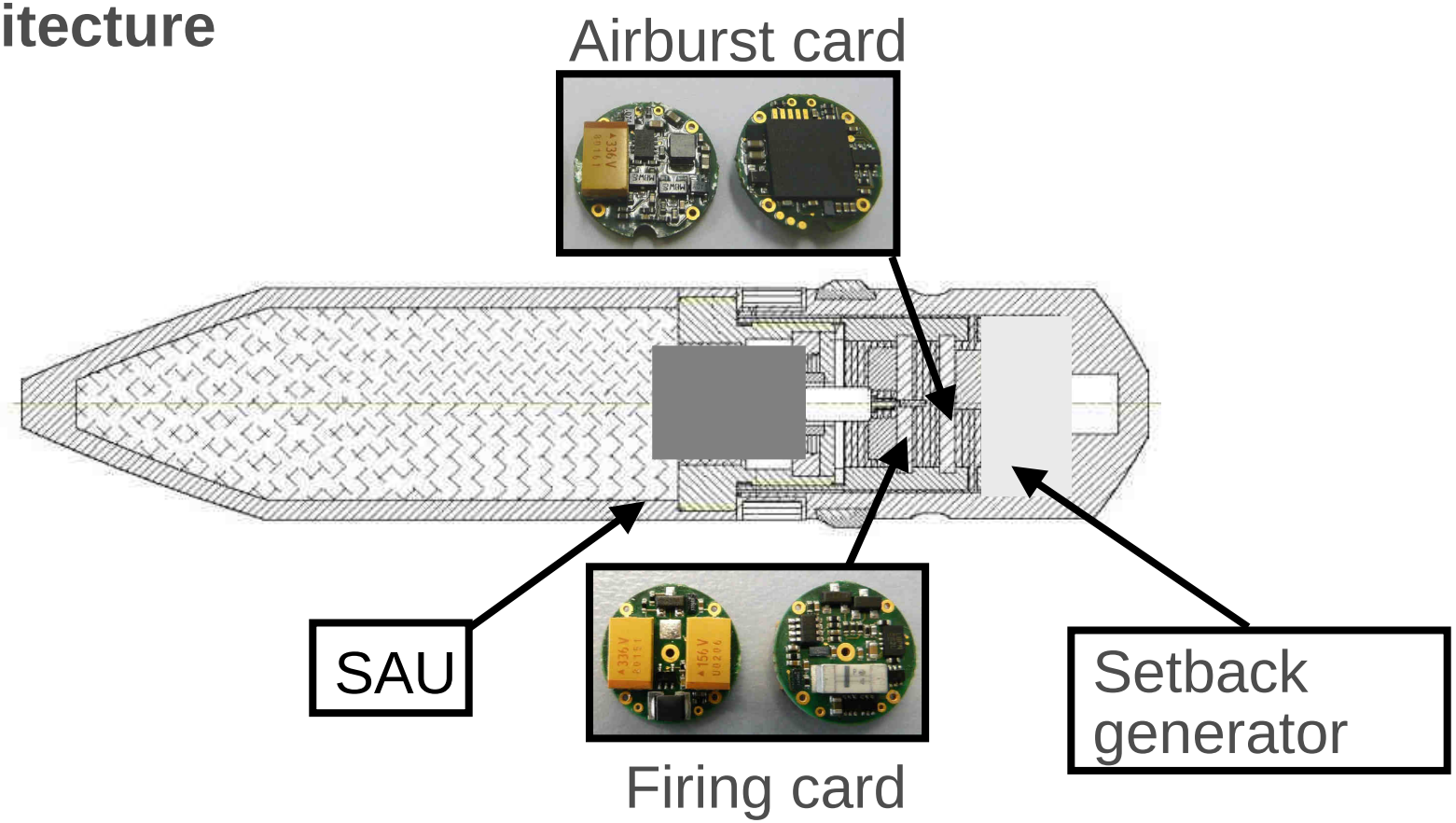
Mk I



- **Programming Unit**
  - Inductive coil (Mode + Chronometry)
  - Impact mode remains available without programming unit
- **Operational modes**
  - Airburst +PD +Self-destruct
- **Airburst performances**
  - Chronometry : **+/- 50 cm** at 1000 m
- **Environment conditions :**
  - Medium calibre 25x137 : 100 000 g 1000rd/s



► Architecture



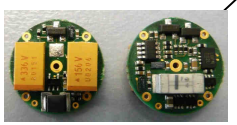
Electronics and SAU designs are deeply fit into each other during engineering process.

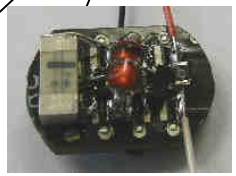
Recorded flight tests

- Accumulated energy is generated by setback acceleration
- Chronometric accuracy assessment
- Detonator firing sequence

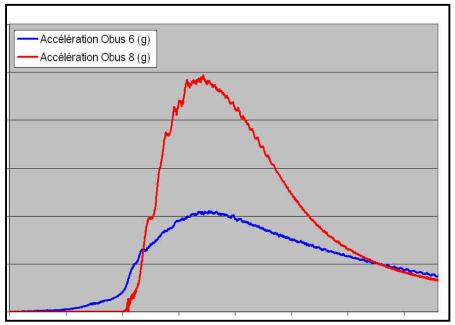
$\Gamma \approx 60\,000g$ et $100\,000g$

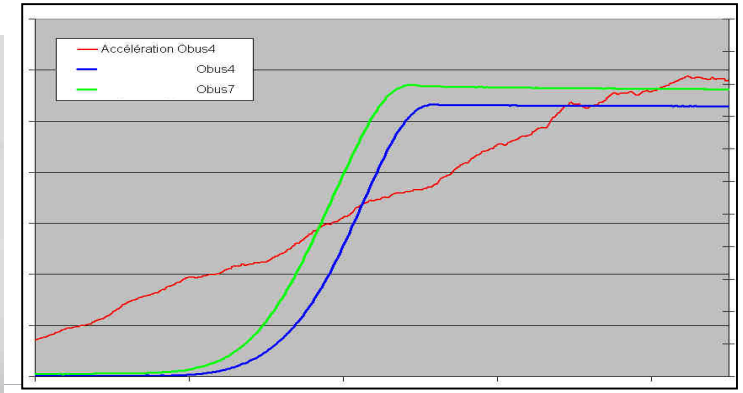
Recording unit





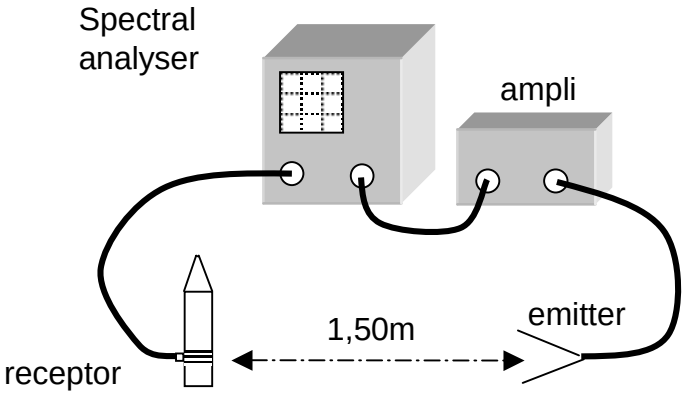
Electronic functions





EMC immunity assessment

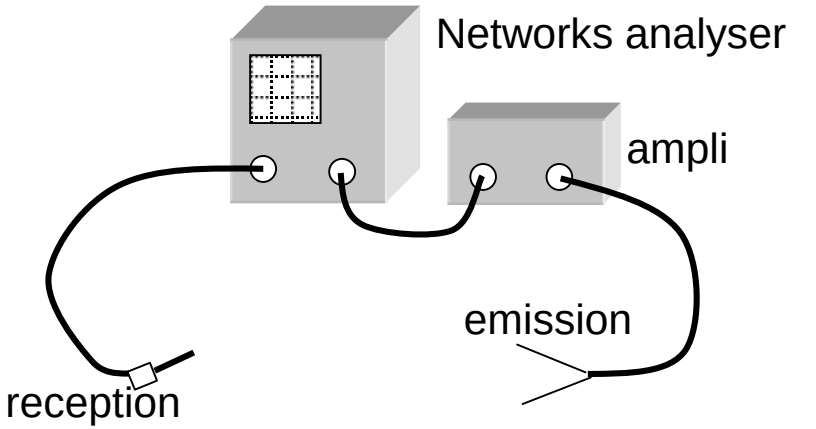
Measures from 2 GHz to 18 GHz



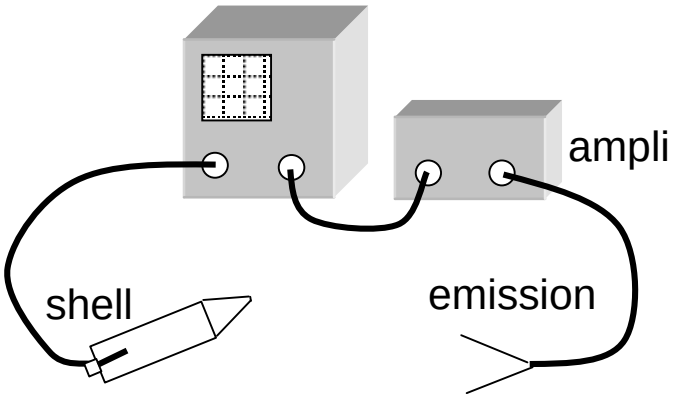
Induced voltage within the round coil is deduced by analysis from measures achieved thanks to vectorized spectral analyser

EMR hazards immunity

Measures from 60 MHz to 18 GHz



STEP 1 : measure of max. level without ammunition



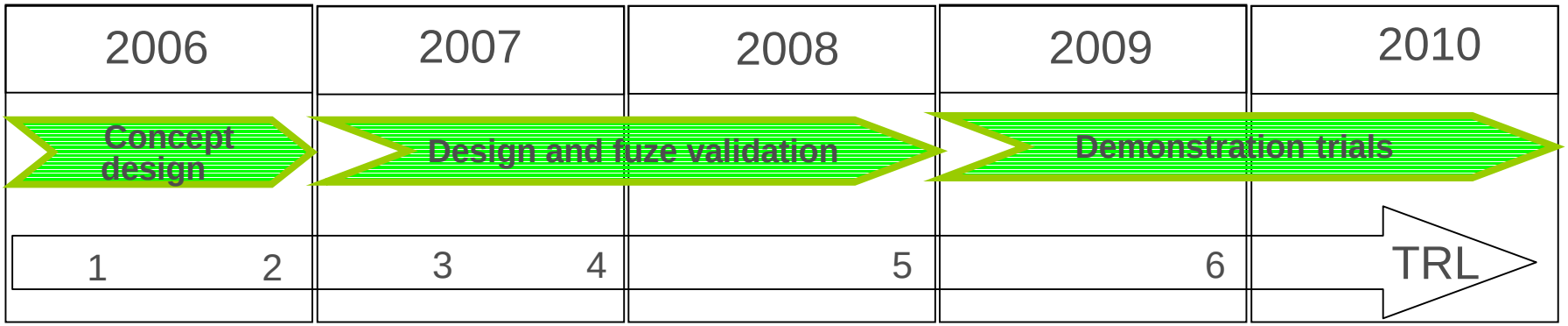
STEP 2 : measure of max. level within ammunition

- **Measures permits to assess the shell faradisation**
- **Analysis permits to evaluate the existing safety margins against EMR aggressions**

Demonstration NEXTER Munitions
French MOD – September 08

Fuze technology – MATURITY LEVELS

Sub-systems or Components	Main Techniques or Technologies Involved	Current TRL
25 mm airburst fuze	Electronics	6



. Conclusion

- **The maturity levels have grown quickly till today**
- **This growth is partially due to the new experimental techniques like in-flight data recorder at high level of acceleration**
- **2009 – 2010 will be the time for the demonstrations tests !**

1. Design & Demonstration of 25mm Airburst ammunition-Mk II

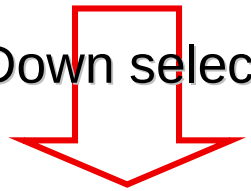
Self-funded study

Synthesis

- Merge both programs (airburst and µSAU)
- µSAU advantages
  - **MEMS technology particularly adapted to Medium caliber ammunition: size & number of ammunition to produce**
  - **Cheaper: electronics industry**
  - **More reliable**
  - **Robust**
  - **Settable for the complete range of medium caliber**

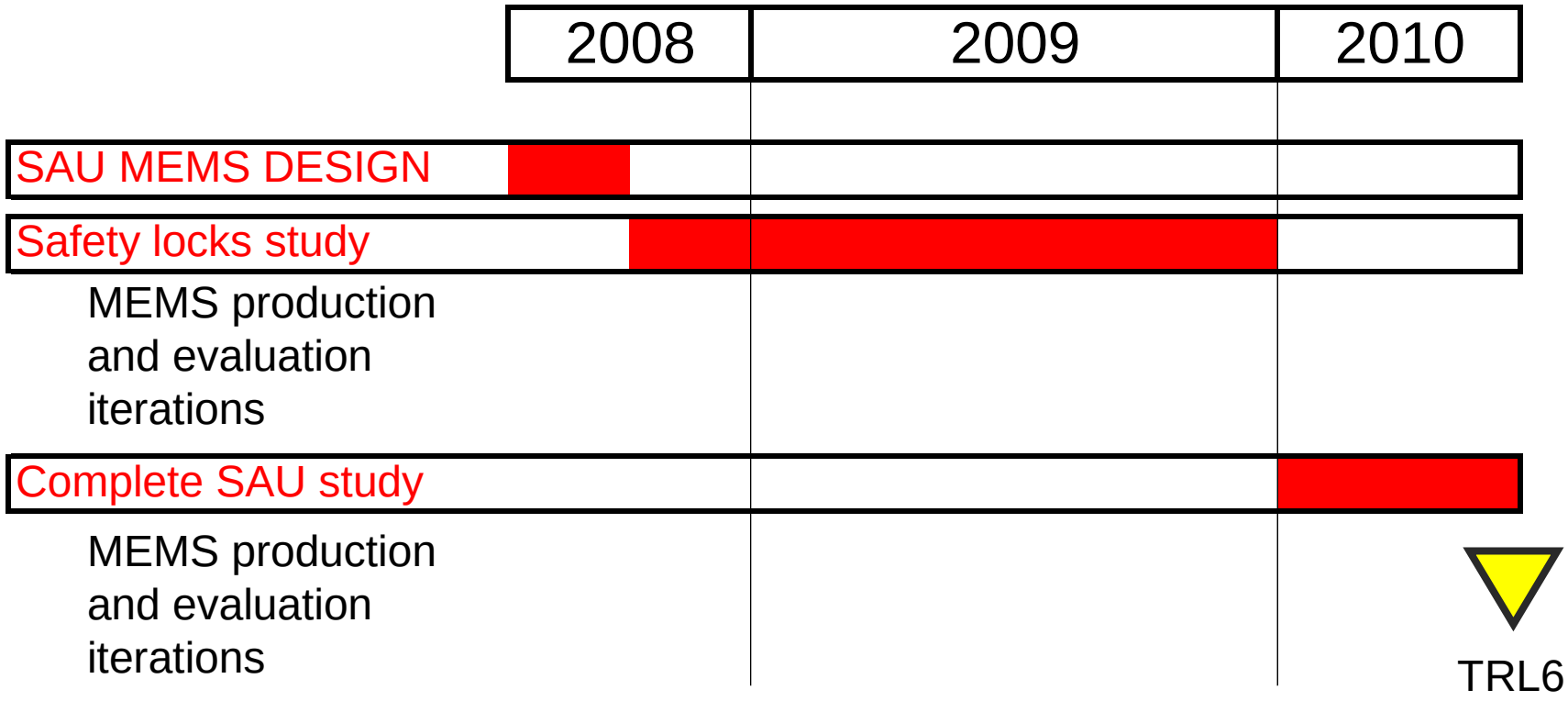
Self funded-study

- µSAU design based on NMu pyro-MEMS experience
- Study of safety locks reacting straighthly to the arming environments
- MEMS SAU designed for electrical ou mechanical detonators
- Workflow
  - **Simulation, static and dynamic tests on each devices (setback & rotation safety lock, motion of the shutter**



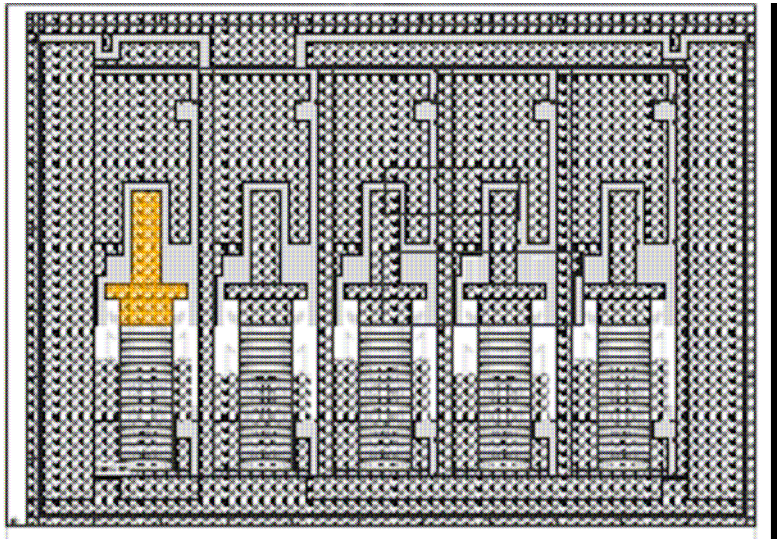
  - **Simulation, static and dynamic tests for the complete MEMS SAU**

Time schedule



Work in progress

- MEMS SAU design done (patended)
- First batch of MEMS produced
- First batch of MEMS tested
  - Structure able to withstand 100.000g
  - Safety locks operate



Thanks to your attention