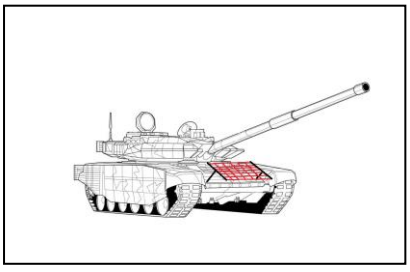
AVERA

Anti-Missile Reactive Net

Filet Réactif Anti-Missile – FRAME / Yield explosive cord or Linear Shaped Charge cord

The Tanks come back in the battle



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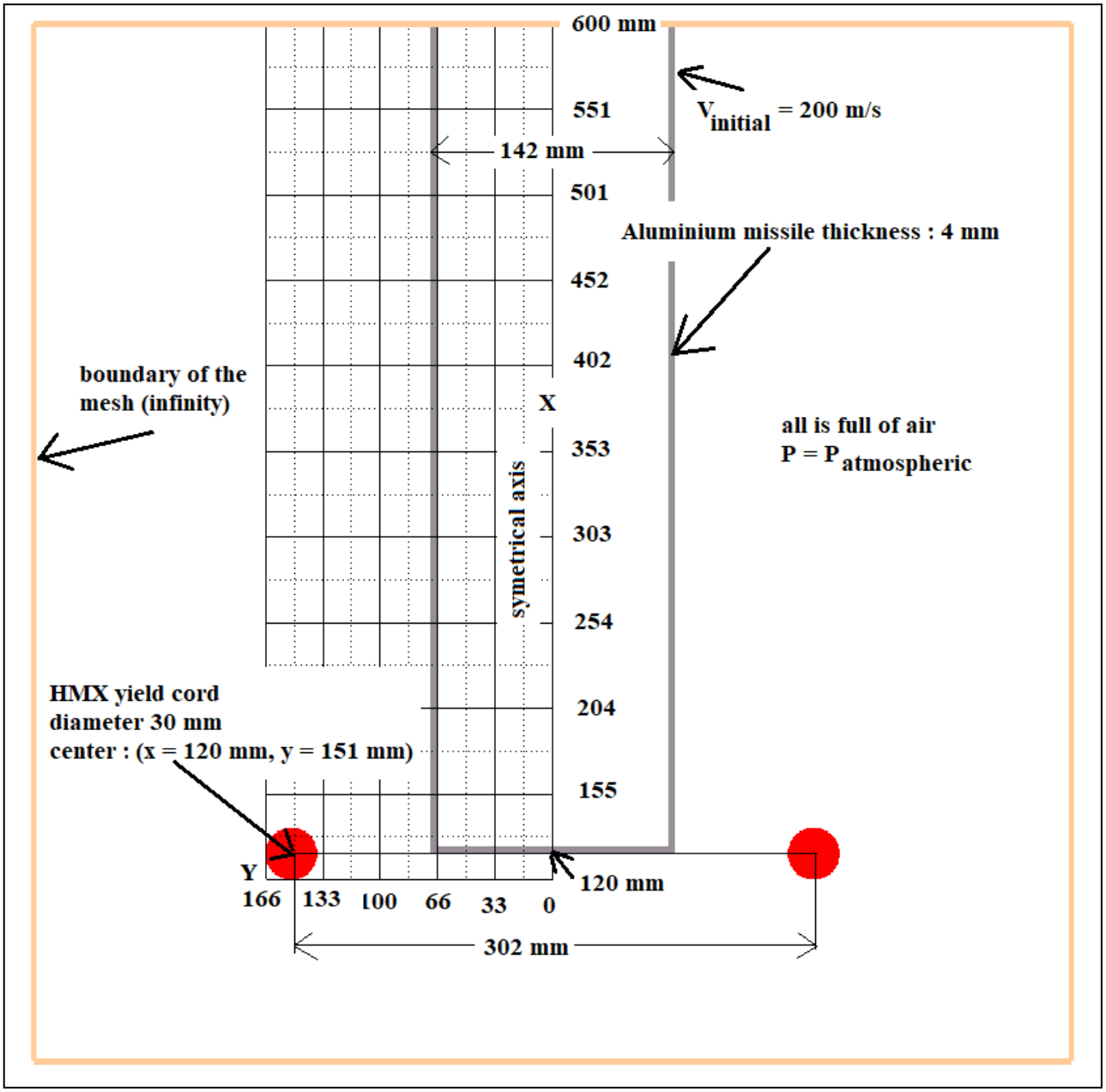
I) Introduction

We study the detonation of a circular yield explosive cord around a missile which is modelised as a cylinder. The linear shaped charge net will be described at section **III**.



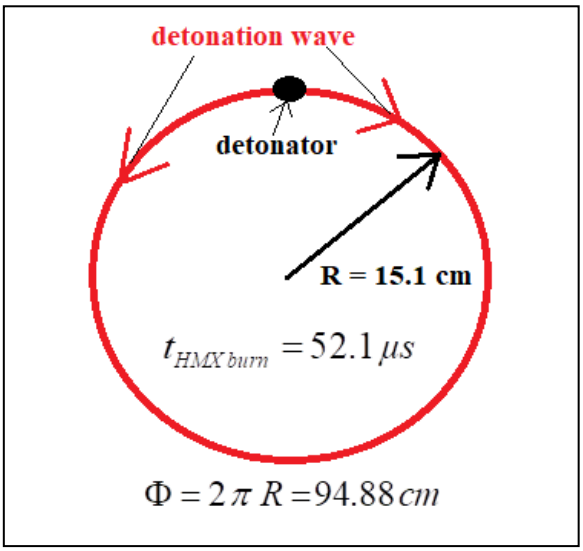
Geometry of the modelisation : 2D axisymetric Euler multimaterials

- Missile has 142 mm diameter (R = 71 mm, top at X = 120 mm, bottom at X = 600 mm = boundary of the mesh) ;
- Circular yield explosive HMX cord has 302 mm diameter (R = 151 mm) ;
- Diameter of yield HMX explosive cord is 30 mm (center coordinates : X = 120 mm, Y = 151 mm).

The yield explosive cord burn instantaneously : pysical justification of this axisymetric modelisation is time elapsed for full burned yield cord and small missile traveling distance during this time.

This is because detonation wave has 9 110 m/s and missile speed is 200 m/s :

the detonation go in the two opposites sides, at right and left of the detonator.



The speed of the detonation wave, the Chapman-Jouguet speed, is for HMX 9110 m/s.

So as the wave goes simultaneously right and left, the time to burn all the yield cord is given by the relation

$$t_{burn} = \frac{\Phi}{2\,D_{CJ}} = \frac{94.88\,cm}{2\times 9.11\times 10^{5}\,cm/s} = 5.21\times 10^{-5}\,s = 52.1\,\mu s$$

where $\Phi = 2\pi R = 94.88\,cm$ is the perimeter of the circle.

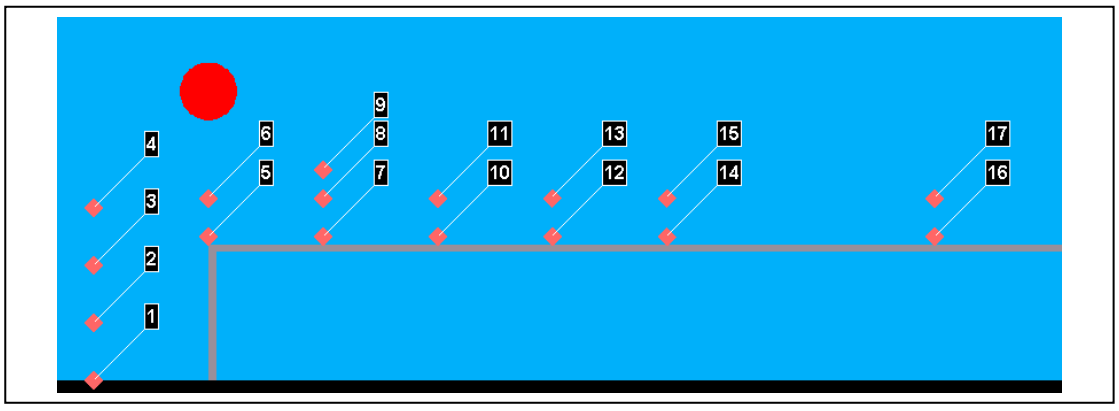
During this time the missile which had a speed of 200 m/s travel a distance give by the relation $d_{missile} = t_{HMX\,burn} \times V_{missile} = 5.21\times 10^{-5}\,s \times 200\,m/s = 1.042\times 10^{-2}\,m$:

$$d_{missile} = 10.42\,mm$$

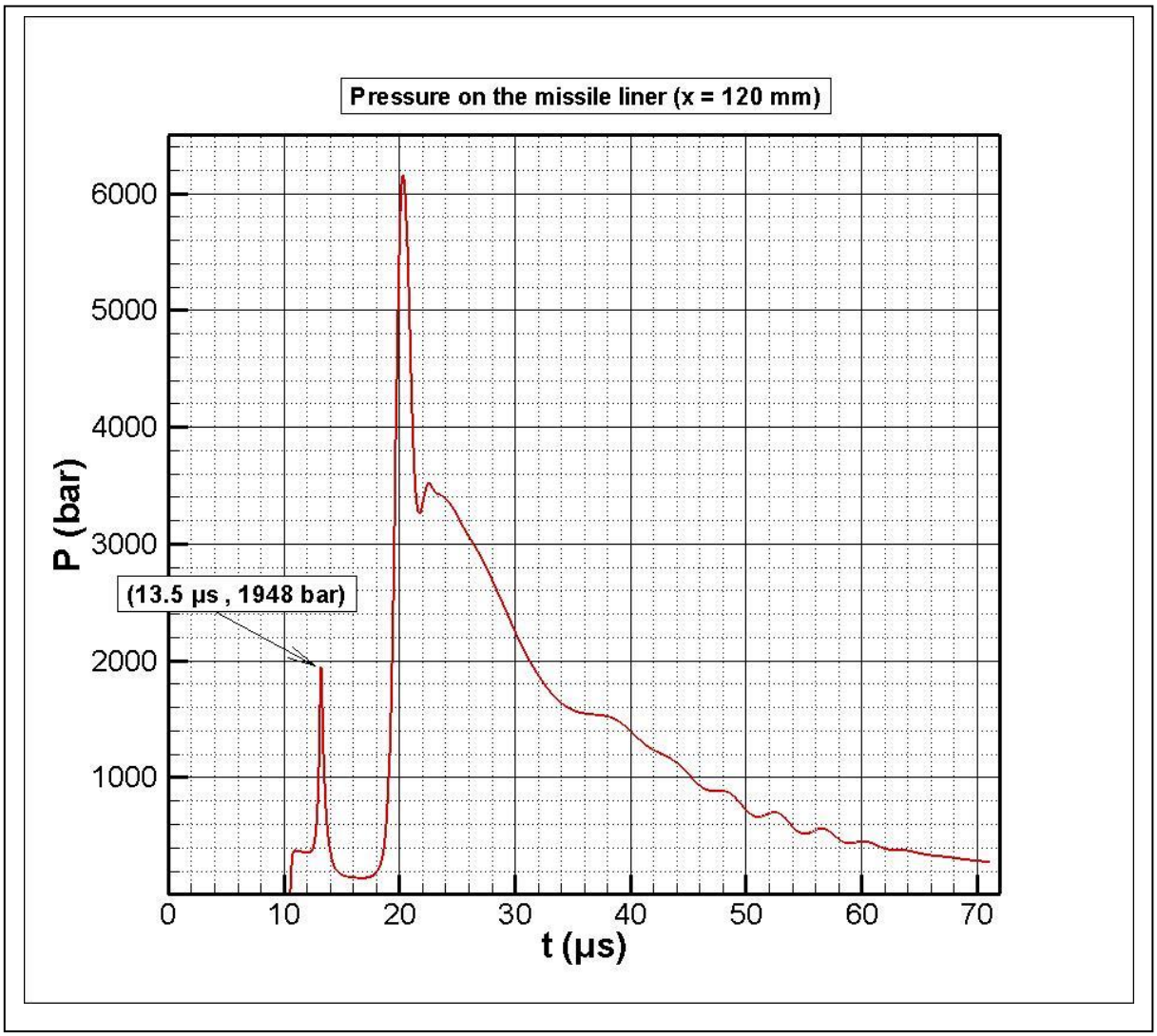
The missile displacement is small enough to accept the instantaneously burning of all the yield HMX cord.

In fact this is a full 3D phenomena, so the shock wave coming from detonator will make less time to hit the missile than sock wave coming from opposite side.

The time the shock wave come from the detonator to the missile liner (4 mm thickness of aluminium) is given by the jauge number 5 (fixed position) :



The time - pressure curve is :



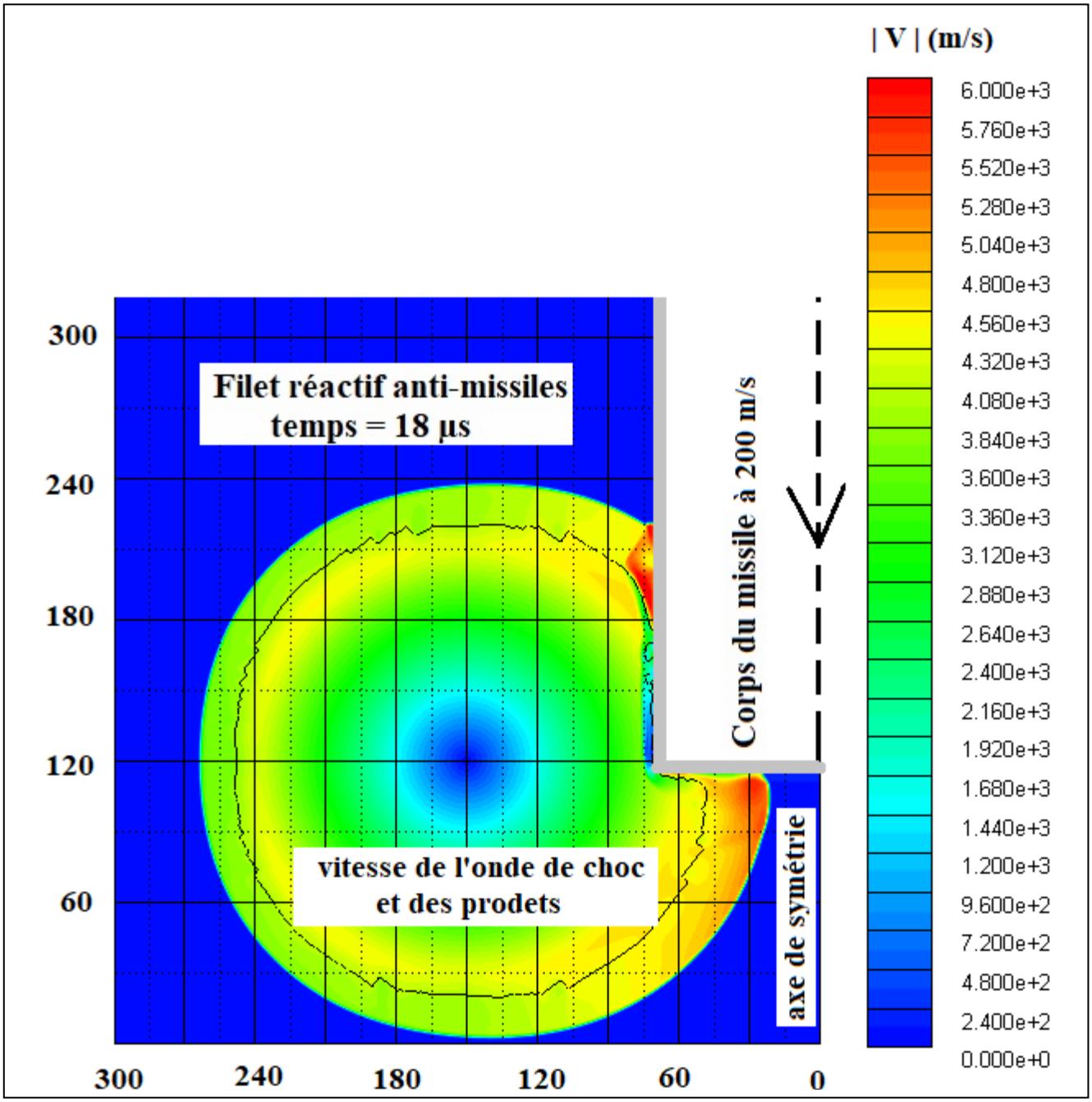
The shock wave from the detonator hit the missile liner at 13.5 µs, which is 38.6 µs before all the yield cord is burned. The missile displacement is 2.7 mm in 13.5 µs, so before the first shock.

Because of inertie of matter, the liner will be crush first from the side close to detonator, but the shock wave coming from other point will implode it too. Only the shape of the liner will be modified because of this not synchrone shock wave impact on missile, but the weapon head of the missile will be destroy by the shock wave coming from all points because displacement of missile is only 10.42 mm when opposite shock wave hit the liner.

It’s interesting to note that even with more « slow » explosives, as for example the insensitive TATB (7600 m/s) or more insensitive FOX-17 (8335 m/s), the 2D approximation is justified. Of course a full 3D modelisation will be interested, but must make only few change to the phenomena obtained with 2D modelisation.

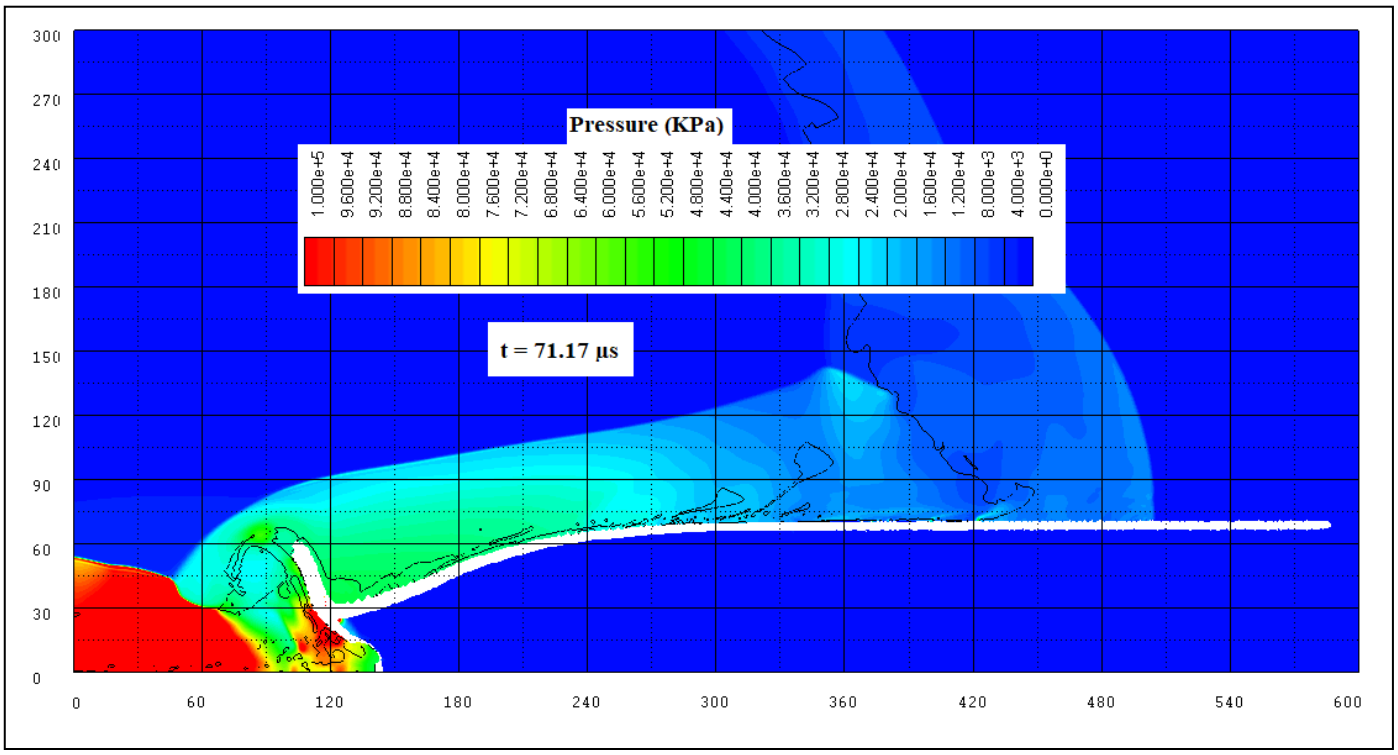
II) Results

The field speed at 19.2 µs show the high speed of the shock wave at the bottom and along the liner, which confirm the high intensity of shock wave coming from detonator side and opposite side.

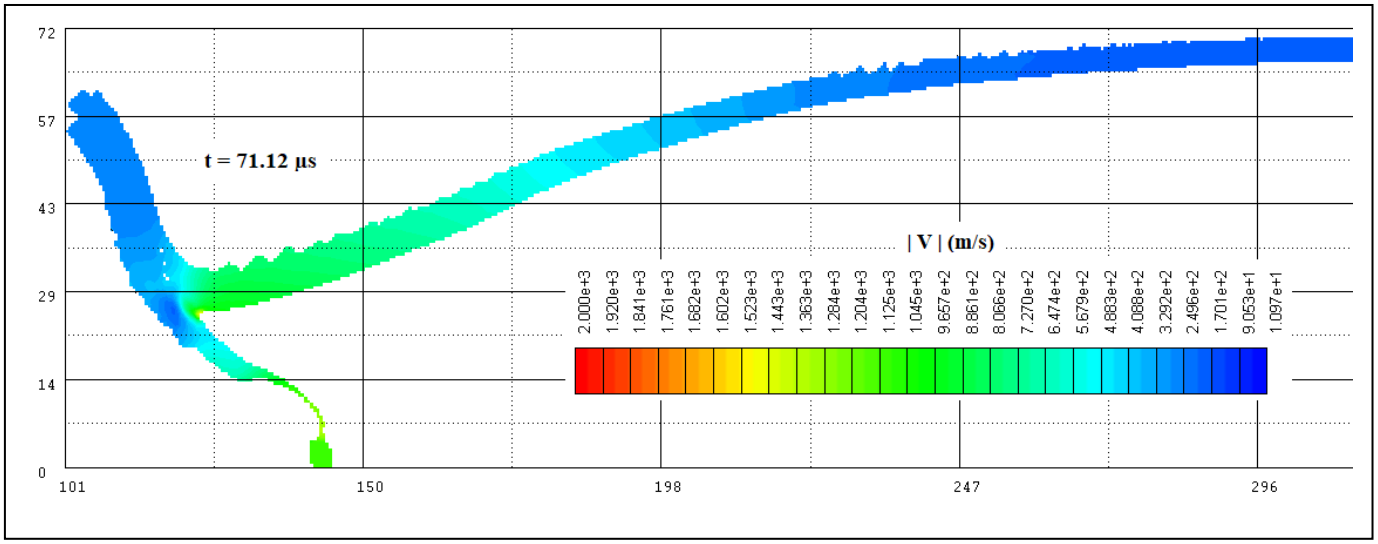


Speed of the gaz around he missile – t = 18 µs

The pressure, in kPa, show a pressure near 450 bars on the head of the missile which is implosed :

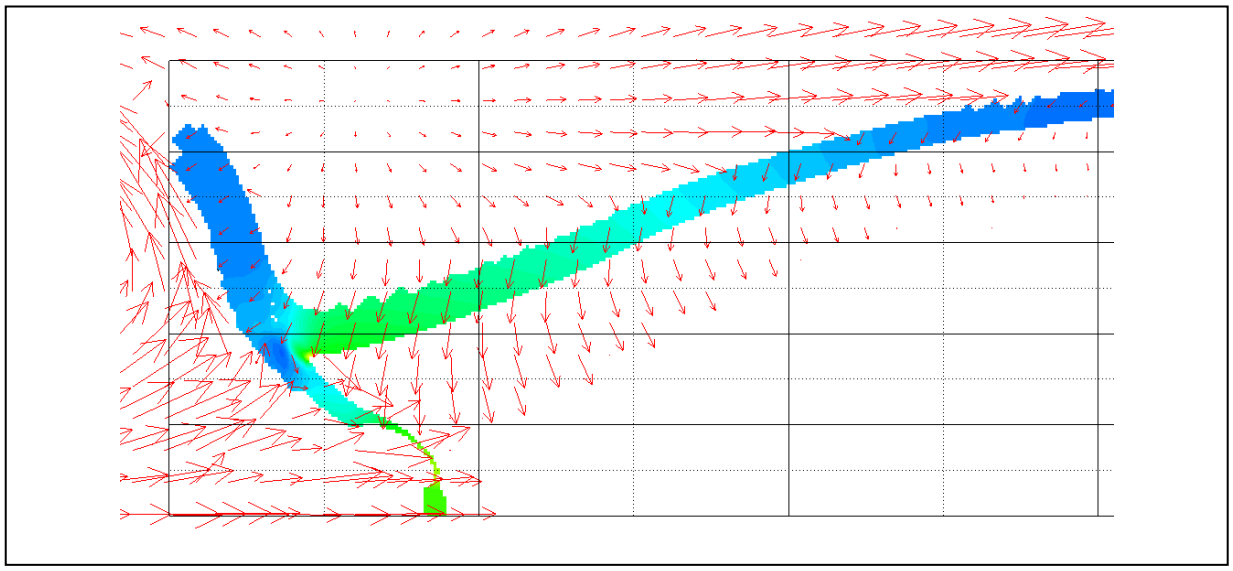


Pressure field around the head of the missile at 71.17 µs - < P > around 450 bars at the top of missile



Field of absolute speed of liner of the missile (zoom near the warhead, direction next page)

Here we can see the **implosion phenomena** : all the vector speed are directed towards the symetric axe :



Implosion of the missile liner : vector speed towards symetric axe ($|V| \approx 900$ m/s)

III) <u>The linear shaped charge net</u>

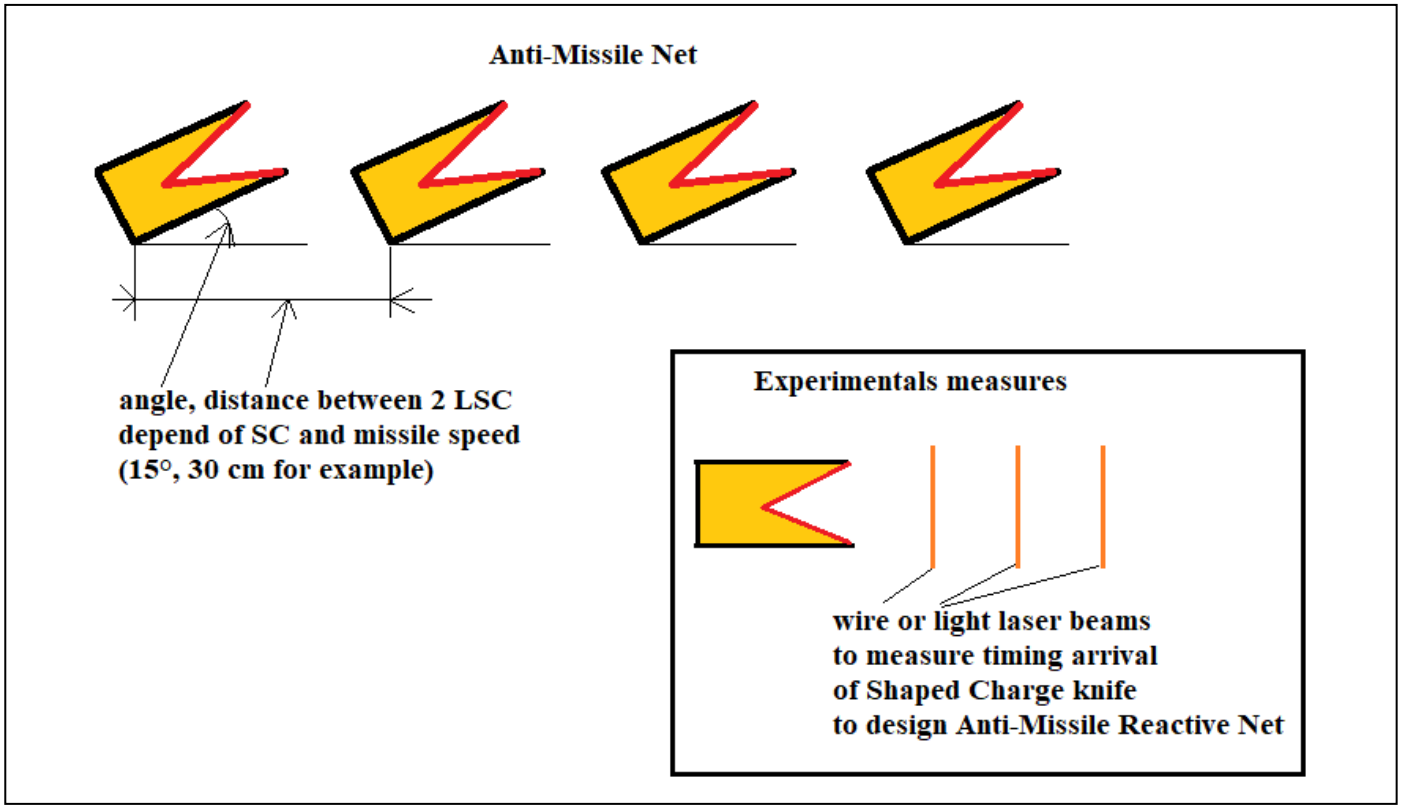
The idea is very simple. I had make 2D plan simulation, long time ago, which show linear shaped charge speed as low than 2 000 m/s, depends of the dimensions of the high yield cord cut as Razor for example.

This is full 3D but the 2D plan results (near 2000 m/s) plus the detonation wave speed, Chapman Jouguet speed, are sufficient to design **this so simple idea that i am surprised nobody had think to before me ☺ !**

So I think experimentals measures of shaped charge knife arrival time are sufficients and necessary. This oan be make with wires net, or photodiod and laser net in front of the linear shaped charge knife.

The net will consist of segments with one detonators at every side, to be more speed, and with some angle (10° – 30°) for the shaped charge knife doesn't impact next linear shaped charge. Every knife can be protected by a plate, corner, to stop smalls fragments of previous knife.

The schemas explains this idea. Of course cells can be make and a lot of mixed configurations can be used.



(*May be Razor society could be contacted to make this Anti-Missile Net experiments !*)

IV) Remarks and conclusion

The use of the Anti-Missile Net Reactive (Filet Réactif Anti-Missile in french – FRAM) show that the missile is imploded when it start go through : syncrhonisation of detonation and missile position is fundamental.

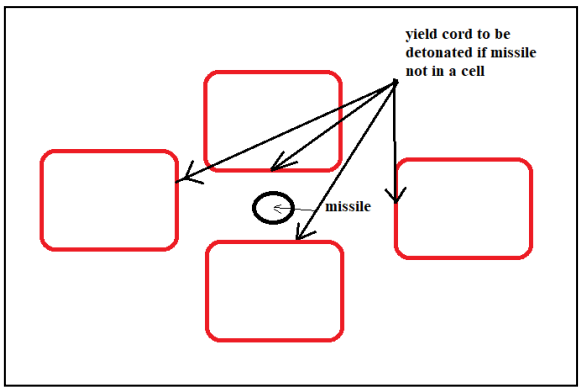
So the missile detection just before it arrive close to the net must be assured by electronic sensor as light net with photodiod, for example, and digital or analogic (more speed) electronic to look at speed.

The fundamental principle is to lie electronic with detonic to assure the **D^3 sequence Detection – Detonation – Destruction** of the missile. Usually, protection of tank by reactive shield not need electronic but only explosive with relatively insensitive property.

The sensibility of explosive use in the net need to be studied for when a cell of the net had destroyed a missile, the other cells needs to be, if possible, intact if a second missile arrive. Even if probability is low because of, may be, other tank which will shot at the place where the first missile had been fired, this must be studied.

There is many explosive with **less and more sensitivity properties**, as ***TATB***, ***FOX-7***, or ***B2238*** wich are usue on tank reactive shiels. All these explosives are described in international articles, from detonic, balistic pyroetchnic symposium and other scientifics journals (Impact engeneering journal, pyrotechnic journal, etc …). We found in these articles all the physical and numericals caracteristics to make good simulations. Even softwares, free or not exist to make these simulations, as LS-Dyna, Autodyn, Uintah (very good free software), MPM free fortran software, or may be **one of the best : 2DE code of Mader** which FORTRAN source is on the CD-Rom of his book : *Numerical modeling of Explosives and Propellant* (this need only to be transform in **FORTRAN 2008** for make no limit on cells number, for example **with a student** of an engineering school - i can help him ☺ !).

In fact it's more simple to use a configuration where cells of the net have no contact between themselves :



Disposition of cells : if missile arrive not in a cell, make the 4 independants yields cords to detonate simultaneously to destroy missile

The distance bettween the yiels cords make, at worth, only the four adjacents cells to detonate. But in fact, it's possible to use independants lines : this is geometrical problem. Of course use of insensitive explosive allow more design. At worth, after one missile had been destroyed, one net need to be change.

For the Linear Shaped Charge net, previous section explained all … ***That's all Folks***