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COST / BENEFIT ANALYSIS OF MURAT Using Club MURAT ACB Software APPLICATION TO THE FRENCH AIR FORCE 500 lb BOMBS

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1 ABSTRACT

Reducing the risks induced by munitions is an obvious priority for NATO armed forces. The purchase over-cost of an IM is usually easy to determine. However, it is the complete munition life cycle cost that must be considered. The purchases over-cost of such a munition needs to be compared with the logistical and operational benefits due to the reduction of risks. This can be done using software such as ACB developed in France by Club MURAT. From the results of such an analysis, the optimum MURAT level can also be determined.
The paper presents the results of such an analysis conducted on ACB by DGA (the French procurement agency) and the French Air Force.
The munitions considered in this example are General Purpose and penetrator versions of 500 lb bombs.
Besides the raw results of this study, the influence of the different parameters on the results was assessed. This has highlighted the importance of logistic regulation.

2 INTRODUCTION

Within DGA (the French procurement agency), INSP/IPE/SM (Munitions Safety Office) is responsible for :

- munitions safety qualification,
- the enforcement of the French MURAT doctrine.

As it is essential to be able to justify the end user with MURAT requirements (in terms of costs versus benefits), a great interest was seen in using software such as ACB, which was developed by Club MURAT.

While previous versions of ACB were already assessed on simplified examples (Air Force and Army munitions), the aim of the study described in this paper was to evaluate the latest version of the software on an actual and concrete example, and so to help the end user in making decisions.

3 THE ACB 2.7 Club MURAT SOFTWARE

3.1 GENERAL

Frank Môller has developed his methodology in the early 90's when he was working at pilot NIMIC. This methodology is based on the fact that the benefit due to an IM solution for a given programme is the result of the following calculation :

  Logistic (Actual) Benefits
+ Potential (Virtual) Benefits
- Acquisition overcosts

This methodology was improved later by Alex White (DSTO - Australia) in the Monte Software, and then adapted by Club MURAT in a user-friendly model called ACB since 1997.

3.2 SOFTWARE PARAMETERS

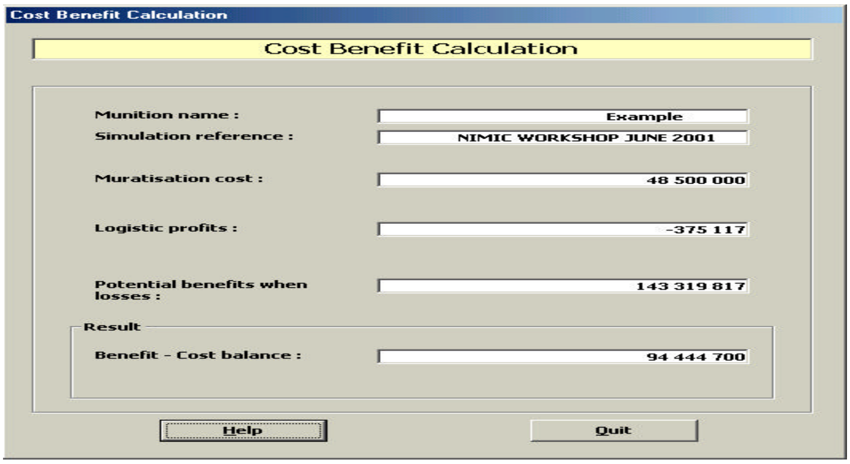
The necessary input data are shared into 5 categories called "screens" :

- Screen 1 :
  - number of considered munitions (inventory)
  - Cost of a reference munition
  - Number of munitions in magazine, by typifying transport, by operation
  - Profile of life (number of years of peace, crisis, war)
  - Numbers of transports and missions (in peace, crisis, war)
- Screen 2 :
  - Variation of the inventory due to the introduction of the planned ammunitions
  - Cost of research and study, development and production costs
  - Variation of the unit cost between munition of the reference and planned munition
- Screen 3 :
  - Disposal cost reducing for planned munition
  - Logistical cost deltas (storage and transportation) between the reference and planned munition
- Screen 4 :
  - Predictable frequency of disasters in storage (per year and by deposit) in times of peace, crisis and fight
  - Predictable frequency of disasters in transport (per year and by deposit) in times of peace, crisis and fight
  - Predictable frequency of disasters in operation (per year and by deposit) in times of peace, crisis and fight

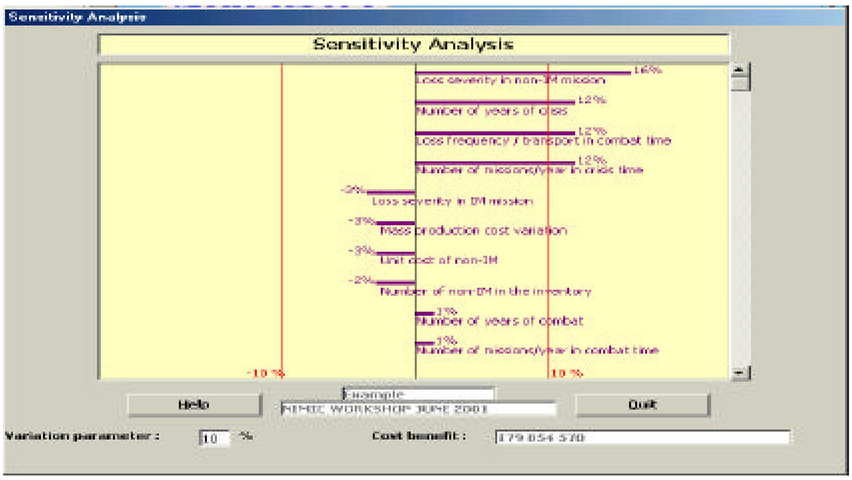
  - Costs induced by disasters connected to the reference munition in storage, transport and operation
  - Costs induced by disasters connected to the planned ammunition in storage, transport and operation
- Screen 5 :
  - Elements of discounting (rate of the long term money, rate of the currency depreciation)

3.3 THE RESULTS

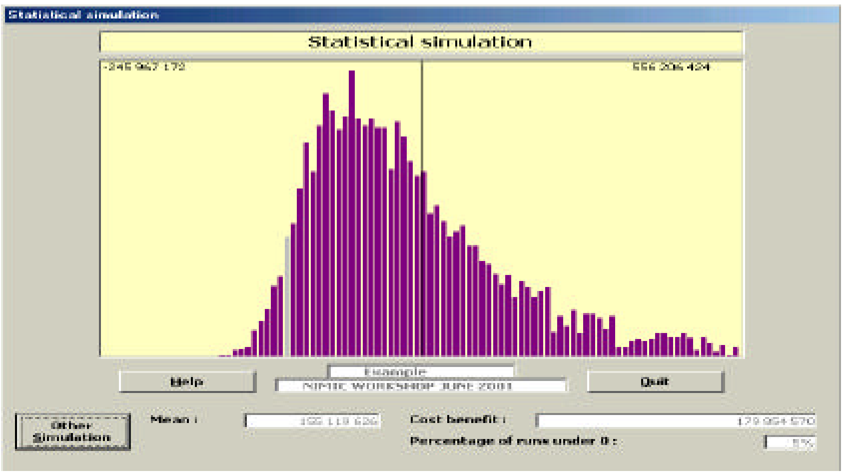
The direct result given by the software shows the overcost of "muratisation", the logistic benefits due the diminution of constraints during storage and transportation (the **actual benefits**), and the potential benefits due to the lower probability of disasters and the lower severity of those disasters if they occur (the **virtual benefits**).



It is also possible to assess the relative influence of the input data by conducting a sensitivity analysis which shows the influence on the final result of a variation of 10% of each parameters :



Finally, a statistical simulation allows to assess the confidence level in the result :



4 FIRST STUDY – THE AIR FORCE 500 lb GP (MK 82 type) BOMB

The choice of the example was based on an actual need recently expressed by the French Air Force. It consists in replenishment activities for 500 lb general purpose bombs (MK 82 type).
While in service bombs are filled with H6 composition, there is an obvious need for the Air Force to go to an IM version. The aim of the study was of course to assess the benefit between the H6 (reference) version and a standard IM version (using PBX N109 as HE filling), but also to assess the benefit in choosing an higher IM level version (using B 2214 insteed of PBX N109).
So two analyses were conducted :

- 1st analysis : reference H6 filling, option 1 PBX N109 filling,
- 2nd analysis : reference H6, option 2 B 2214 filling.

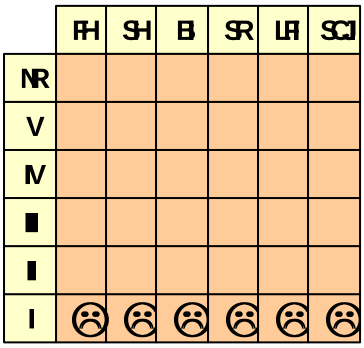
In those analyses, just the body of the bomb was considered. Paveway kits and fuzes were not taken into account, except when evaluating the financial consequences of an accident.

The organisms involved in that study were :

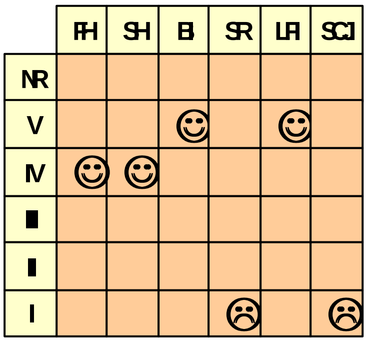
- DGA/INSP/IPE/SM, the munitions safety office which is national authority for munitions safety qualification,
- DGA/SPAé : the munitions program office for the Air Force,
- EMAA (Air Force staff)/Logistics office and Armament Systems office,
- Club MURAT.

4.1 IM SIGNATURE

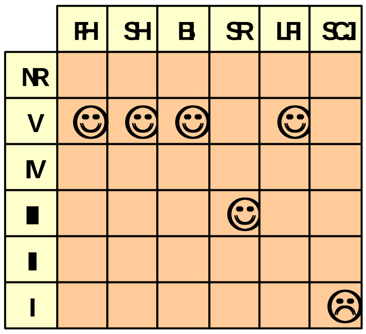
The ACB analysis is based on a comparison between the reference and the option. So were just taken into account the potential accidents – and corresponding stimuli - for which the response of the munitions is different.
This was done looking at the "IM Signature" of the different versions considered, as defined in NATO AOP 39 :



H6 filling version (reference)



PBX N109 version (option 1)



B 2214 version (option 2)

From those signatures, it appears that :

- the behaviour of the PBX N109 is much better than the reference when subjected to impacts (bullet or fragments) or heating (slow or fast),
- the behaviour of the B 2214 version is just slightly better than the PBX N109 version when subjected to heating,
- the main difference between the 2 options is the no-sympathetic detonation of the B 2214 version.

4.2 THE INPUT DATA

According to the 5 screens described at §3.2, the input data defined for the study are given in the tables below :

SCREEN 1, GENERAL DATA

Number of munitions for the analysis	1500
Number of munitions in magazine	200 (igloo) and 50 (shelter)
Number of munitions in transport	24 (road) and 48 (air)
Life cycle	25 years (peace 23.2, crisis 1.5, war .3)

Those data are very dependent of the political context which is continuously evolving.

SCREEN 2, DIRECT COST DELTA OF IM

	Option 1 (PBX N109)	Option 2 (B 2214)
Extra munitions necessary	0	0
R&D, production facilities, …	0	0
Requalification	550 k$	600 k$
Unit cost delta	+ 60 %	+ 140 %

It is considered that the technologies and production facilities were already developed for other applications.

SCREEN 3, LOGISTICAL COST DELTA

	Option 1 (PBX N109)	Option 2 (B 2214)
Storage costs	No variation	No variation
Transportation costs	No variation	No variation
Demilitarization	1500 $/munition	1500 $/munition

Today, and because of the interpretation of the regulation, the Air Force doesn't take into account the benefit of Unit Risk.

SCREEN 4, THE POTENTIAL ACCIDENTS

	Option 1 (PBX N109)	Option 2 (B 2214)
Type of accident considered	**Fuel Fire** (during peacetime, crisis and war)	**Fuel Fire** (during peacetime) **Fuel Fire and Bombing** (during time of crisis and war)

Are just considered the types of accidents for which the gravity is modified, according to the IM signature.
Because of the lack of data, it is obvious that it is very difficult to defined figures for the probability and gravity of accidents.

SCREEN 5, DISCOUNTING

Long term rate for the money 6 %
Depreciation of the money 2 %

4.3 THE RESULTS

	Option 1 (PBX N109)	Option 2 (B 2214)
Purchase cost delta	+ 60 %	+ 140 %
Benefit (as % of the purchase cost of the reference)	300 % 520 % *	250 % 490 % *
Benefit (as % of the purchase cost delta)	500 % 870 % *	180 % 350 % *

* : if the discounting is not taken into account

For each of the two analysis conducted in this study, the apparent benefit is very high but is mainly a virtual benefit coming from a reduction in terms of gravity of potential accidents.
This virtual benefit has to be compared to an insurance.

More interesting is to consider that the benefits coming from option 1 and those coming from option 2 are similar. This means that the purchase cost delta between B 2214 and PBX N109 versions is "virtually" balanced by the reduction of risks due to sympathetic reaction hazards.

While the Air Force was ready to go from the H6 filling to the PBX N109 version, the choice is open to go to the B 2214 version, which is more expensive but will prevent from sympathetic reaction hazards.

5 SECOND STUDY – THE 500 lb PENETRATOR (CBEMS type) BOMB

Those last years, the Navy has developed such a penetrator version of the 500 lb bomb. Having to go onboard the CVN Charles-de-Gaulle, a high IM level was required for this bomb and a B 2214 version was chosen.
Today, the Air Force has expressed a need for such a penetrator, but with less stringent IM requirements. So was envisaged to change the B 2214 filling for a PBX N109 filling.
The aim of this second study was to evaluate the benefit of this PBX N109 option compared to the existing B 2214 version (to be considered in this study as the reference).
In this study, because of the cost of the penetrator body itself, the influence of the explosive filling on the purchase cost of the munition is much lower than for the general purpose version of the bomb.

5.1 IM SIGNATURE

The signature of the 2 versions is not changed compared to the GP versions analysed in the first study.
Those signatures show that the main difference between the 2 version is the sympathetic detonation of the PBX N109 option.

	FH	SH	BI	SR	LFI	SCJ
NR						
V	☺	☺	☺		☺	
IV						
III				☺		
II						
I						☹

B 2214 version (reference)

	FH	SH	BI	SR	LFI	SCJ
NR						
V			☺		☺	
IV	☺	☺				
III						
II						
I				☹		☹

PBX N109 version (option)

5.2 THE INPUT DATA

Of course, most of those data are unchanged compared to the first study.

SCREEN 1, GENERAL DATA

Number of munitions for the analysis	500
Number of munitions in magazine	200 (igloo) and 50 (shelter)
Number of munitions in transport	24 (road) and 48 (air)
Life cycle	25 years (peace 23.2, crisis 1.5, war .3)

Because of the specificity of this munition, we are considering the purchase of 500 units (insteed of 1500 in the first study).

SCREEN 2, DIRECT COST DELTA OF IM

	Option (PBX N109)
Extra munitions necessary	0
R&D, production facilities, …	0
Requalification	70 k$
Unit cost delta	- 20 %

The technologies and production facilities were already developed for the Navy needs.
Of course, the PBX N109 version is cheaper than the B 2214 reference.

SCREEN 3, LOGISTICAL COST DELTA

	Option (PBX N109)
Storage costs	No variation
Transportation costs	No variation
Demilitarization	0

The same methods are used for demilitarization.

SCREEN 4, THE POTENTIAL ACCIDENTS

	Option (PBX N109)
Type of accident considered	**Fuel Fire** (during peacetime, crisis and war) **Bombing** (during time of crisis and war)

Are just considered the types of accidents for which the gravity is modified, according to the IM signature :

- *no sympathetic detonation of the reference B 2214 when subjected to bombing,*
- *type V for the reference (instead of type IV for the PBX N109 option) when subjected to fast or slow heating.*

SCREEN 5, DISCOUNTING

Long term rate for the money	6 %
Depreciation of the money	2 %

5.3 THE RESULTS

	Option (PBX N109)
Purchase cost delta	- 20 %
Benefit (as % of the purchase cost of the reference)	6 % 10 % *
Benefit (as % of the purchase cost delta)	57 % 36 % *

* : if the discounting is not taken into account

There is an apparent benefit which indicates that the end user could be content with the PBX N109 solution. But this benefit is rather low and could even become a loss if the input data are slightly modified.
So the conclusion is again that the lower purchase cost of the PBX N109 option is "virtually" balanced by the increase of risks due to sympathetic reaction hazards.
And again the choice appears open for the Air Force between the existing B 2214 version, which is more expensive but will prevent from sympathetic reaction hazards, and a cheaper but more hazardous PBX N109 version.
However, a very important factor not taken into account in this analysis is the interoperability of Air Force and Navy ammunitions. This should incite the Air Force to select the B 2214 version already selected by the Navy.

6 CONCLUSION

Besides the raw results of those analyses, the main interest of the study was to better assess the ACB software, and to identify the necessary improvements for a more friendly use and a better relevance of outputs.
The main comments are :

- To be relevant, the analysis must be based on a very well defined life cycle of the munitions. This is very difficult to define, especially because of the evolution of political context, strategies and logistical rules;
- In the 2.7 version of ACB, the calculation is just possible for elementary scenario. A complete analysis is the sum of elementary results, which makes the definition of corresponding inputs rather complicated. This will be improved and in the 3.0 version of the software, it will be possible to take the complete life cycle of the munitions directly into account.
- The relative weight of the "virtual" benefits in the final result is of course very important. This benefit is coming from potential accidents for which it is very difficult to determine the probability. Life cycle of munitions is evolving and it is almost impossible to consider data – if there are – from past experience.
- Very interesting output is the relative weight of parameters. From this, it is possible :
    - to more precisely evaluate and quantify those key parameters,
    - to identify possible evolution of the life cycle or of logistical rules that could modify the result (increase a benefit, or change a loss into a benefit).
- The taking into account of unit risk in the regulation could appreciably modify the balance between actual and virtual benefits.