CONSTRUISONS ENSEMBLE
LA DÉFENSE DE DEMAIN

AOP 39:
RESPONSE DESCRIPTORS

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Division Expertise Programmes
DGA Missiles Testing

Sponsored by IPE

CONTENT

I. BRIEF REMINDER

a. AOP39 ed.2

- **Pros**:

→ Relatively simple classification

→ Focused on accessible effects and information (overpressure, fragmentation, projections)

- **Cons**:

→ Quantitative criteria defined whatever the ammunition ⇒ not adapted to ammunitions with a lot of EM, dependence on case type

I. BRIEF REMINDER

a. AOP39 ed.3

- Focused on the EM way of decomposition → Difficulties to identify it!
- Improvement thanks to the removal of quantitative criteria (except 15m/20J)
- New difficulty → Different interpretations according to the experts

II. IMPROVEMENT NEEDED

a. Different assessment between experts

- Same tests can result into different reaction type regarding the experts
  - Response descriptors are not enough specific
  - Experts need a guide to be sure that different experts in different countries have the same understanding of response descriptors

- **French position** : same test MUST result into the same reaction type

II. IMPROVEMENT NEEDED

b. Casing materials

- 20J curve : relative to a steel fragment
- What if the fragment is into another material ?
- **French position** : adapt the 20J curve to the material

III. FRENCH APPROACH

a. Objectives

- Keep the spirit of AOP39 ed.3
- Do not return to the limits of AOP39 ed.2
- A more efficient help for the interpretation of reaction levels

III. FRENCH APPROACH

b. Principle

i. Projection criterion

- 2 parts:

  - One related to lethality → Use of energy of projection (mass x distance)

  - Another one related to the impact probability → Number of fragments

- Method normalised to avoid the case of one fragment just above the curve “threshold”.

ii. Blast criterion

- Based on thresholds relative to the energetic potential for a detonation of the specimen

  - Its biggest interest is to distinguish a detonation from a non detonation.

III. FRENCH APPROACH

c. In practice

- Application of the method on 52 tests already interpreted

- Ammunitions concerned:

  - 18 missiles with propellant only
  - 10 propellants with packaging
  - 8 missiles with military head only
  - 4 complete missiles
  - 2 shells
  - 8 cartridges with propulsive system only
  - 2 complete cartridges

47 tests in accordance with the assessment

III. FRENCH APPROACH

d. As a guide but not an absolute method

- Reasons why there are 5 tests not in accordance:

  - Propulsion
  - "Gun shot" effect

- These events remind us this method must stay a reliable guide for the expert and not legitimate.

Spirit of AOP39 ed.3

- Finally, a simple analysis of the expert explains the differences

Reliable method

III. FRENCH APPROACH

e. The spreadsheet

Research of new quantitative criteria (keeping current spirit)...
nterpretation of IM tests according to AOP-39 Ed.X thanks to ratio "blast" and "projections"

Modifié le 12/03/2015 par YG
Types of fragments and volumic mass associated

TYPES OF FRAGMENTS

Steel	7,8	g/cm3
Aluminum	2,7	g/cm3
Energetic material	1,8	g/cm3

Munition

MMA	2,500 kg
M_{INERT}	5,000 kg
EqTNT	1,2
$MTNT_{max}$	3,000 kgTNT

IM test (blast pressure)

$\delta P_{mesured}$	20,0 mbar	20,0 mbar	calculated
Distance	5,00 m	0,0 mbar	difference
Ground shock reflexion	2	**B RATIO**	
$MTNT_{mesured}$	0,001 kgTNT	0,03%	

REACTION LEVEL PROPOSAL AOP-39 Ed.X

B RATIO	P RATIO	TYPE
0,03%	14,16%	V

DGA EM

Method developed by France, DGA EM (YG, FC, NK)
at the instigation of IPE, take over from Florian Pechoux

Fragmentation Factor (N)

constante_N	4,00E-01
exposant_N	5,00E-01

IM test (projections)

N	7	fragments including Mo (+1)
∑mi	0,300 kg	Mass sum of recovered fragments

User handbook

White cells : input data
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- MMA : EM weight (B6)
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- Additional graphs are available on spreadsheet Mapping & Thresholds and speadsheet Reaction type

Check Type V vs IV (1, 1)

P_{IV} RATIO: 14,16%

Difference to type IV/type V threshold curve measurement

Nature, mi & pi (mi)			
Energetic material	0,025 kg	14,00 m	2,03%
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MINISTÈRE DE LA DÉFENSE

DGA

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e. The spreadsheet

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Munition input data

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Different 20J curves according to the type of material

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$MTNT_{max}$	3,000 kgTNT	$MTNT_{mesured}$	0,001 kgTNT	0,03%	

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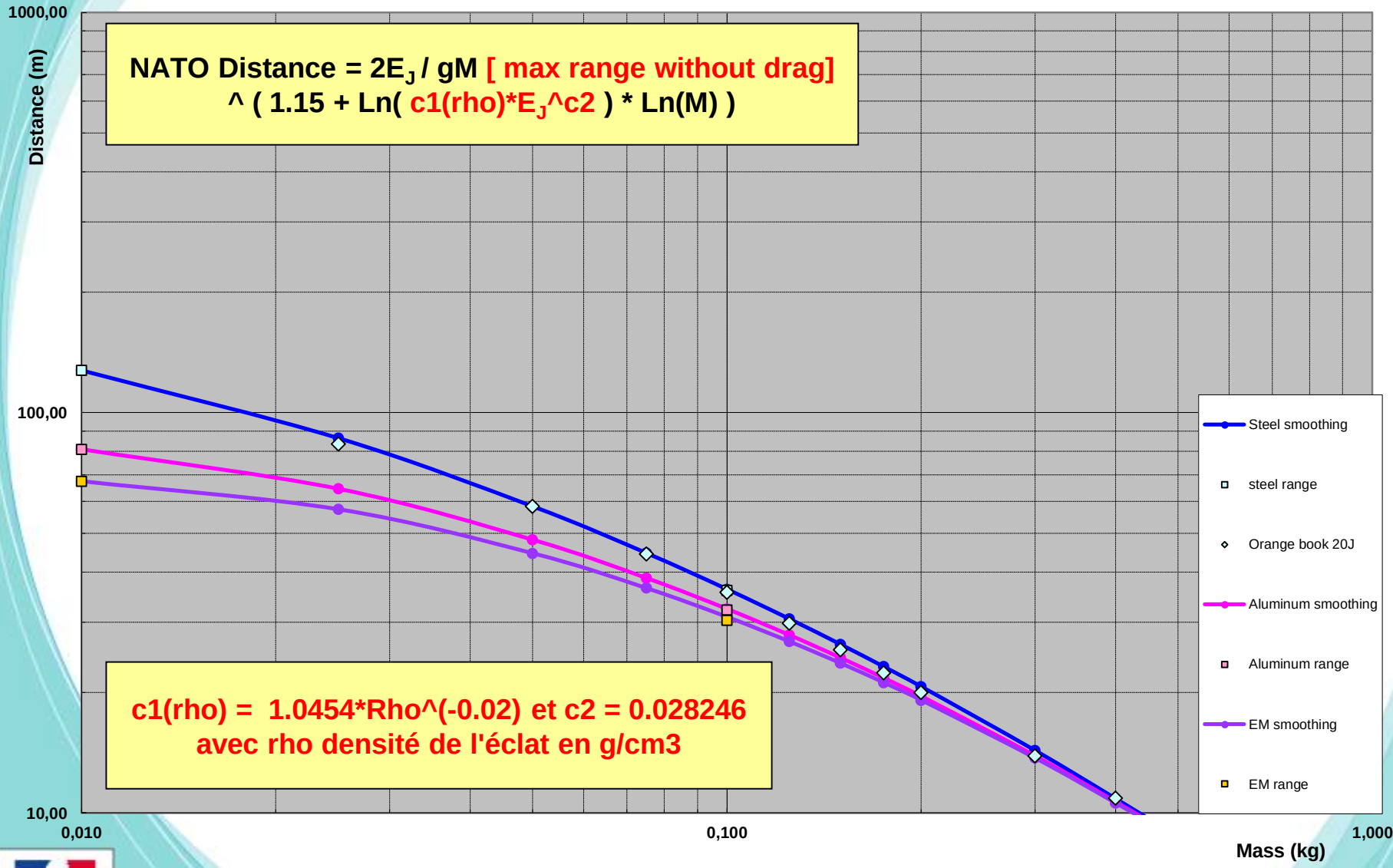
Curves 20J

Metallic fragments steel, aluminum and energetic fragments



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$$f(N)\sum \frac{m_i}{\sum m_i}\frac{p_i}{C_{threshold}}$$

Impact Probability

Lethality

N: number of fragments

f(N): amplification coefficient vs. number of fragments

Σm_i: mass of fragments collected

m_i: mass of the fragment i

p_i: range of the fragment

$C_{threshold}$: curve “threshold”

- limit type III/IV: linked to curve 30m/80J
- limit type IV/V: linked to curve 15m/20J

e. The spreadsheet

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nterpretation of IM tests according to AOP-39 Ed.X thanks to ratio "blast" and "projections"

Modifié le 12/03/2015 par YG
Types of fragments and volumic mass associated

TYPES OF FRAGMENTS

Steel	7,8	g/cm3
Aluminum	2,7	g/cm3
Energetic material	1,8	g/cm3

Munition

MMA	2,500 kg
M_{INERT}	5,000 kg
EqTNT	1,2
$MTNT_{max}$	3,000 kgTNT

IM test (blast pressure)

$\delta P_{mesured}$	20,0 mbar	20,0 mbar	calculated
Distance	5,00 m	0,0 mbar	difference
Ground shock reflexion	2	**B RATIO**	
$MTNT_{mesured}$	0,001 kgTNT	**0,03%**	

REACTION LEVEL PROPOSAL AOP-39 Ed.X

B RATIO	P RATIO	TYPE
0,03%	14,16%	V

DGA EM

Method developed by France, DGA EM (YG, FC, NK)
at the instigation of IPE, take over from Florian Pechoux

Fragmentation Factor (N)

constante_N	*4,00E-01*
exposant_N	*5,00E-01*

IM test (projections)

N	7	*fragments including Mo (+1)*
∑mi	0,300 kg	*Mass sum of recovered fragments*

User handbook

White cells : input data
Grey cells : output data or numeric factors

1 - Fill the munition data cells :
- MMA : EM weight (B6)
- M_{INERT} : inert weight (B7)
- EqTNT (B8)

2- Fill the blast pressure data cells :
- $\delta P_{Measured}$ (E6)
- Distance (E7)
- Ground shock reflexion (E8)

3 - Launch the solver to get the measured TNT equivalent weight : $MTNT_{measured}$ (E9)

4 - Projections
- Number of fragments (E13)
- Fill the mapping area :
-> cells N18:P43. If needed, add rows but ONLY IN THE MIDDLE (between rows 19 and 42)
-> information needed : nature, mass and range

5 - Results are shown in cells I7 to K9
- Additional graphs are available on spreadsheet Mapping & Thresholds and speadsheet Reaction type

Check Type V vs IV (1 / 1)

Nature, mi & pi (mi)

P_{IV} RATIO: 14,16%

Difference to type IV/type V threshold curve measurement

Nature	mi	pi	Difference
Energetic material	0,025 kg	14,00 m	2,03%
Steel	0,027 kg	11,00 m	1,20%
Energetic material	0,063 kg	12,00 m	6,30%
Steel	0,110 kg	0,50 m	0,55%
Steel	0,057 kg	2,00 m	0,71%
Steel	0,002 kg	3,50 m	0,01%
Energetic material	0,016 kg	24,00 m	2,01%
			0,00%
			0,00%
			0,00%
			0,00%
			0,00%
			0,00%
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			0,00%
			0,00%
			0,00%
			0,00%

Check Type IV vs III (1 / 1)

Nature, mi & pi (mi)

P_{III} RATIO: 4,98%

Difference to type III/type IV threshold curve measurement

Nature	mi	pi	Difference
Energetic material	0,025 kg	14,00 m	0,86%
Steel	0,027 kg	11,00 m	0,50%
Energetic material	0,063 kg	12,00 m	2,13%
Steel	0,110 kg	0,50 m	0,16%
Steel	0,057 kg	2,00 m	0,25%
Steel	0,002 kg	3,50 m	0,02%
Energetic material	0,016 kg	24,00 m	0,98%
			0,00%
			0,00%
			0,00%
			0,00%
			0,00%
			0,00%
			0,00%
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			0,00%
			0,00%

MAPPING (IMPUT FIELD)

Nature	Mass	Range
Energetic material	0,025 kg	14,00 m
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Energetic material	0,063 kg	12,00 m
Steel	0,110 kg	0,50 m
Steel	0,057 kg	2,00 m
Steel	0,002 kg	3,50 m
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	0,000 kg	0,00 m
	0,000 kg	0,00 m
	0,000 kg	0,00 m
	0,000 kg	0,00 m
	0,000 kg	0,00 m
	0,000 kg	0,00 m
	0,000 kg	0,00 m
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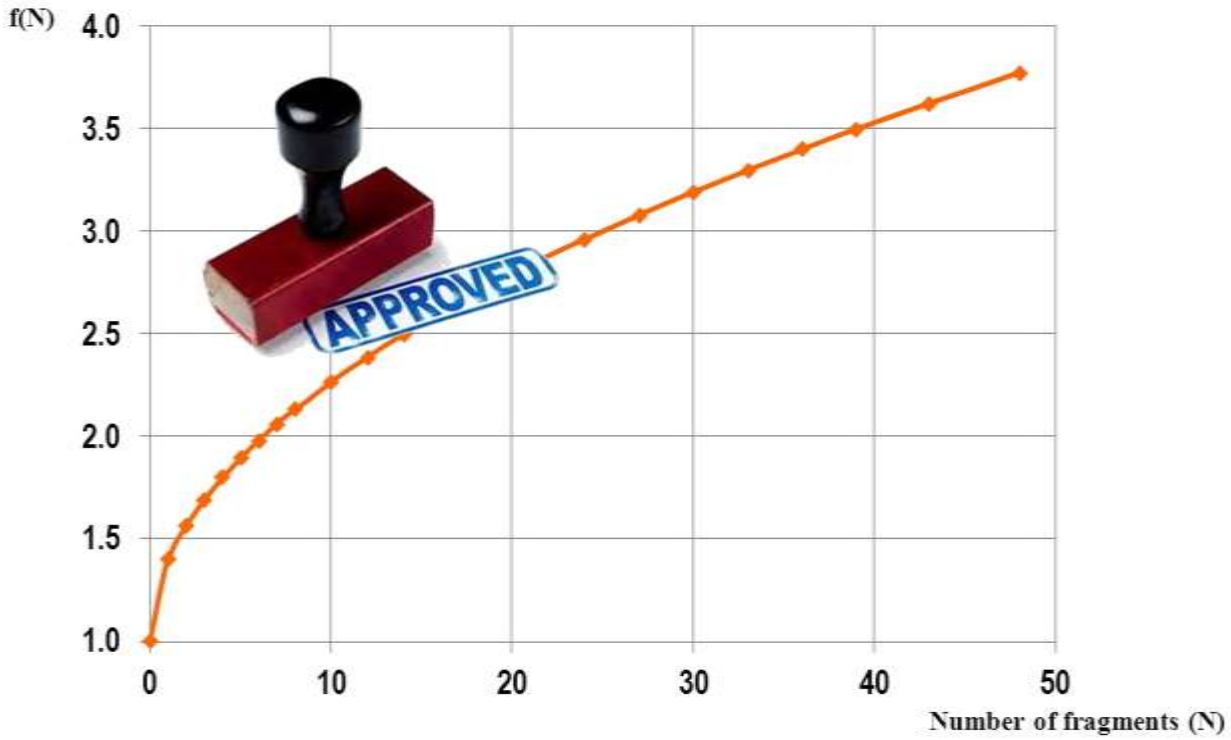
	0,000 kg	0,00 m
	0,000 kg	0,00 m
	0,000 kg	0,00 m
	0,000 kg	0,00 m

Fragmentation Factor



Curve determined thanks to the 52 tests

III. FRENCH APPROACH

e. The spreadsheet

Research of new quantitative criteria (keeping current spirit)...
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REACTION LEVEL PROPOSAL AOP-39 Ed.X

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Check Type V vs IV — P_{IV} RATIO: 14,16% — *Difference to type IV/type V threshold curve measurement*

Check Type IV vs III — P_{III} RATIO: 4,98% — *Difference to type III/type IV threshold curve measurement*

Check Type V vs IV: Nature, mi & pi (mi)	1	1		Check Type IV vs III: Nature, mi & pi (mi)	1	1		MAPPING (IMPUT FIELD)		
Energetic material	0,025 kg	14,00 m	2,03%	Energetic material	0,025 kg	14,00 m	0,86%	Energetic material	0,025 kg	14,00 m
Steel	0,027 kg	11,00 m	1,20%	Steel	0,027 kg	11,00 m	0,50%	Steel	0,027 kg	11,00 m
Energetic material	0,063 kg	12,00 m	6,30%	Energetic material	0,063 kg	12,00 m	2,13%	Energetic material	0,063 kg	12,00 m
Steel	0,110 kg	0,50 m	0,55%	Steel	0,110 kg	0,50 m	0,16%	Steel	0,110 kg	0,50 m
Steel	0,057 kg	2,00 m	0,71%	Steel	0,057 kg	2,00 m	0,25%	Steel	0,057 kg	2,00 m
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Energetic material	0,016 kg	24,00 m	2,01%	Energetic material	0,016 kg	24,00 m	0,98%	Energetic material	0,016 kg	24,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
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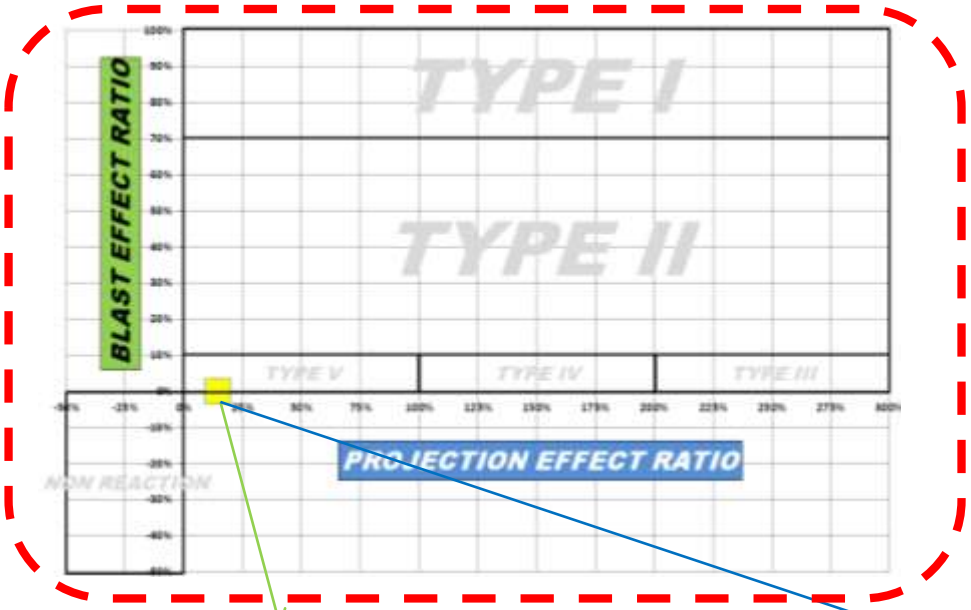
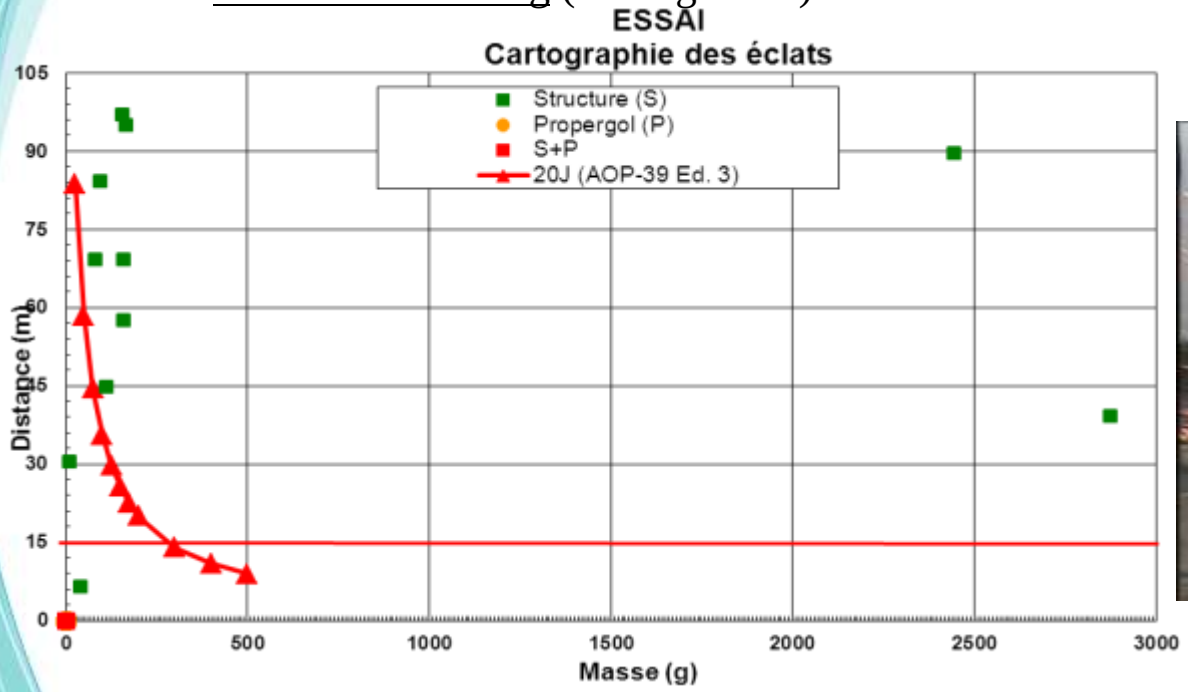
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m
			0,00%				0,00%		0,000 kg	0,00 m



Reaction level	Blast	Projections
Type I	MEqTNT measured/Potential > 60-80%	
Type II	10-20% < MEqTNT measured/Potential < 60-80%	
Type III	MEqTNT measured/Potential < 10-20%	$f(N)\sum_{1}^{N} m_i \frac{p_i}{C_{threshold\ III/IV}} > 100\%$
Type IV		$f(N)\sum_{1}^{N} m_i \frac{p_i}{C_{threshold\ IV/V}} > 100\%$
Type V		$f(N)\sum_{1}^{N} m_i \frac{p_i}{C_{threshold\ IV/V}} < 100\%$
Type VI	No blast	No projections

IV. ILLUSTRATIONS

- APTE: SCO testing (15 fragments)



- AOP39 ed.3: type III

- French speadsheet: type III → New method: type III

IV. ILLUSTRATIONS

- <u>SCJ testing with propulsion</u>

- Assessment of the expert with present AOP39 ed.3: type IV with propulsion

- Assessment with new method: Type IV with propulsion

N° point	Nature Structure (S) Propergol (P) Explosif (E) Débris (D)	Angle en degré	Distance en mètre	Masse en g
1	Structure	342.5915	1.250	542.5
2	Structure	15.4665	8.776	6350
3	Structure	72.1920	3.958	166.5
4	Structure	49.9595	4.260	34.2
5	Structure	227.2260	10.085	62.5
6	Structure	225.0325	12.111	23.8
7	Structure	332.1140	27.241	1.8
8	Structure	180.0000	3.450	8.5
9	Structure	245.8500	7.113	12

MINISTÈRE DE LA DÉFENSE

DGA

IV. ILLUSTRATIONS

- <u>SCJ testing with propulsion</u>

- Assessment of the expert with present AOP39 ed.3: type IV with propulsion

- Assessment with new method: Type IV with propulsion

1. Excel speadsheet: type V

IV. ILLUSTRATIONS

- <u>SCJ testing with propulsion</u>

- Assessment of the expert with present AOP39 ed.3: type IV with propulsion

- Assessment with new method: Type IV with propulsion

1. Excel speadsheet: type V

2. Expert (video analysis)  self-propelled element almost returned to its initial position type IV with propulsion

Whatever the present method or the French proposal, an expert cannot assess the reaction as a type IV with propulsion without watching the video.

CONCLUSION

- **Advantages**:

  We keep the spirit of the AOP39 ed.3

  An average of the results of projections / removal of particular cases
  (Avoid the case where 1 fragment is above the curve 15m/20J whereas all evidences conclude to a type V)

  Creation of a tool to help the experts to decide

  The results prove the reliability of the method: the most important!

THANK YOU FOR YOUR ATTENTION

ANY QUESTIONS ?

For more informations :
GO TO POSTER SESSION