Modelling of Warhead Response to Projectile Impact with TEMPER Software

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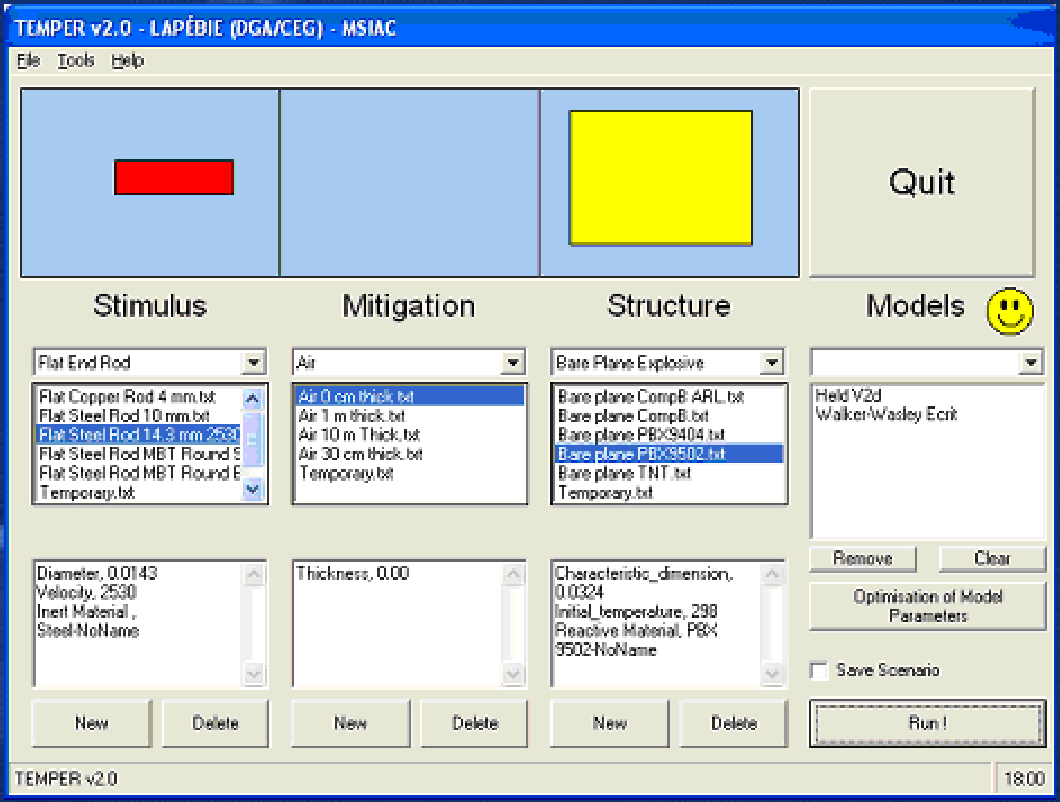
TEMPER Software

New Modelling Improvements:
- Covered Explosive
- NATO Fragment

Application Example

BACKGROUND

- **Toolbox of Engineering Models to Predict Explosive Reactions**
- **Designed to aid in the prediction of the response of munitions to mechanical or thermal threats**



FEATURES : Objects and models

STIMULI

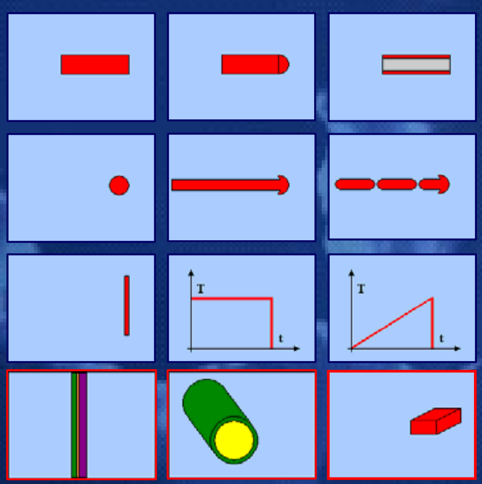
Flat end rod
Round end rod
Flat cookie-cutter
Spherical fragment
Simple shaped charge jet
Real shaped charge jet
Thin plate
Constant Temperature
Rising Temperature
Multilayer Impactor 1D
One on One Warhead
Parallelepiped Fragment

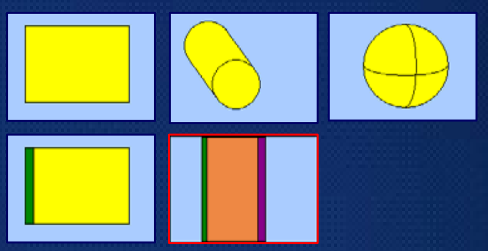
MITIGATIONS

Air
Single layer
Spaced plates

STRUCTURES

Bare plane explosive
Bare cylindrical explosive
Bare spherical explosive
Covered plane explosive
Multilayer Structure 1D





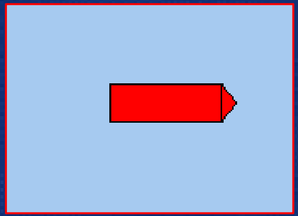
MODELS

V^2d and u^2d (Held)
E_{crit} Walker-Wasley
E_{crit} James
Y (Yactor) [modified]
$V_{threshold}$ (Jacobs-Roslund)
$t_{cook\text{-}off}$ (Creighton-Victor)
E_{seuil} and BSDT (Peugeot)
Godlag 1D (Baudin)

New Modelling Work

STIMULI

New projectile



- **Conical-ended projectile**
- **Main goal:**
  - Modelling the NATO fragment defined in STANAG 4496 for IM evaluations (ϕ 14.3 mm and 160° cone angle)

MODELS

V^2d and u^2d (Held)
E_{crit} Walker-Wasley
E_{crit} James
Y (Yactor) [modified]
$V_{threshold}$ (Jacobs-Roslund)
E_{seuil} and BSDT (Peugeot)

- **8 models available to model shock response**
- **Only one relevant for covered explosive: Jacobs-Roslund (JR)**
- **JR use limited by a lack of sets of parameters**
- **Work carried out to correlate JR parameters with explosive shock sensitivity (gap test)**
- **Main goal:**
  - Modelling of warheads with very limited restrictions on explosive compositions

Jacobs-Roslund Model

- **Empirical model**
- **Critical impact velocity for target detonation related to explosive sensitivity, fragment size and shape and cover thickness:**

$$V_{threshold}(t,d) = \frac{A}{d^{0.5}}(1+B)(1+C\frac{t}{d})$$

d = fragment diameter

A = explosive sensitivity coefficient

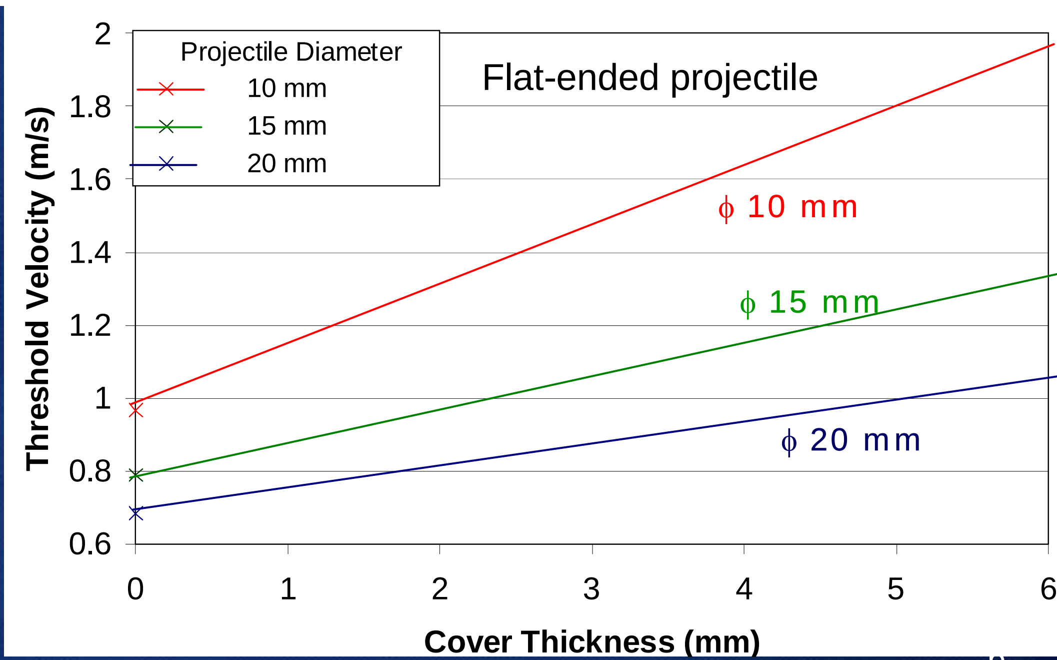
B = projectile shape coefficient

0 for flat-ended

close to 1 for round-ended

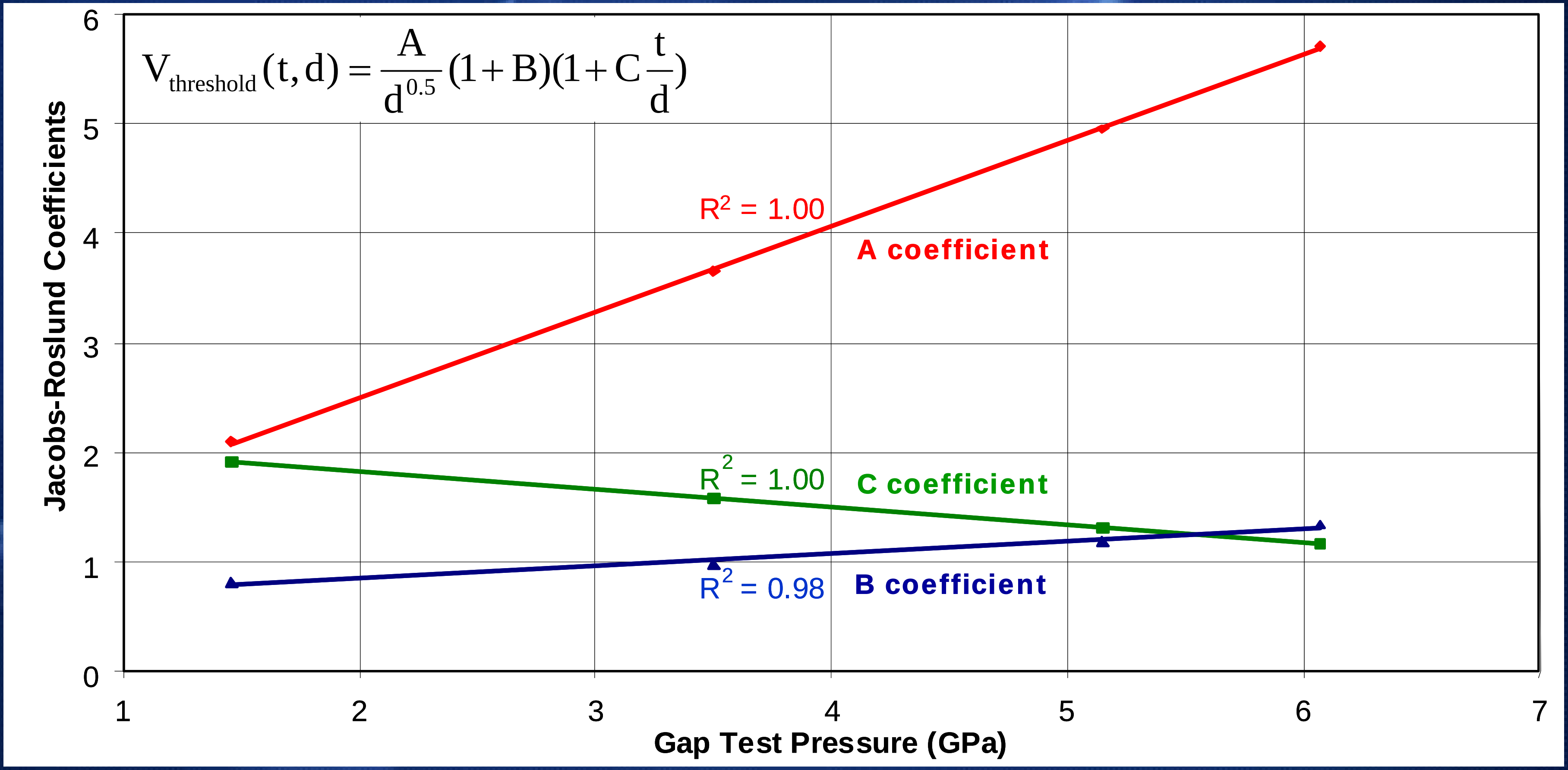
C = cover plate protection coefficient

t = warhead cover thickness



Jacobs-Roslund Model

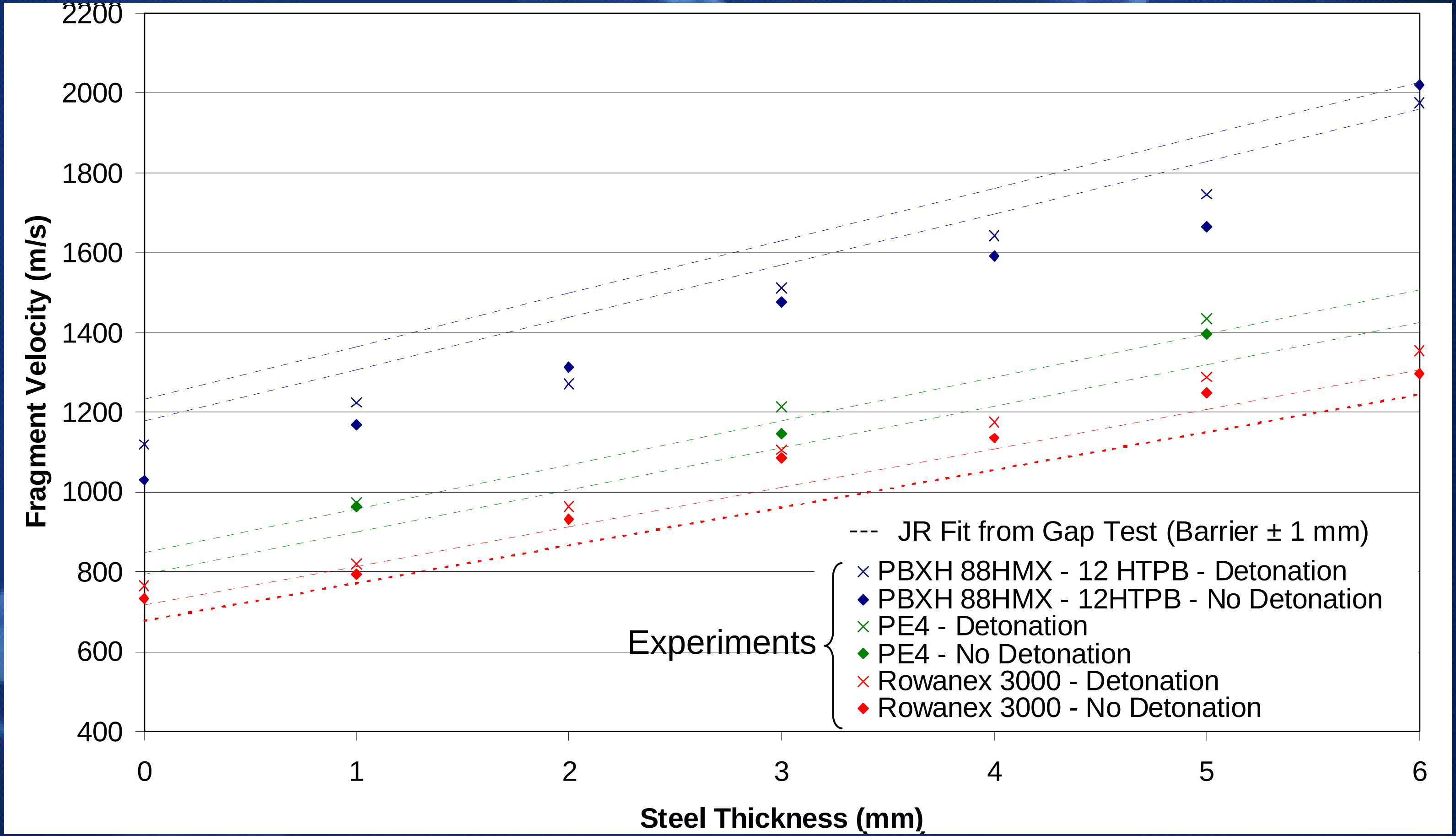
- **Jacobs-Roslund parameters for various explosives have been compared to explosive shock sensitivity determined from large scale gap test (LSGT).**



- **Excellent correlation**

Jacobs-Roslund Model

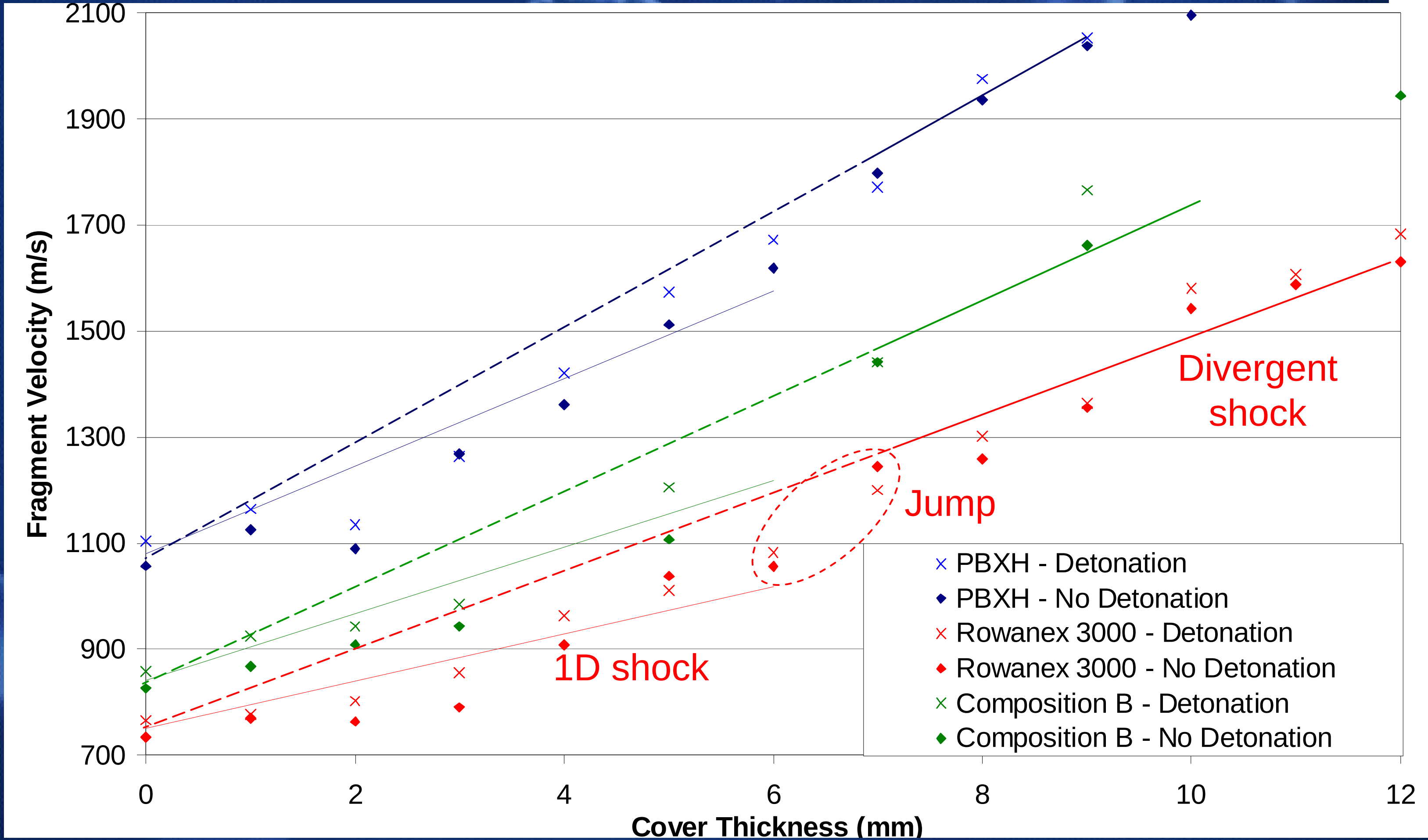
- **Approach validated for various explosives whose LSGT shock sensitivity was known but not JR parameters**



- **Bare threshold slightly under- or over-estimated (± 5 to 9%)**
- **Curve slope well-fitted in cover thickness range [0;6 mm]**

Jacobs-Roslund Model

- For thicker cover than 6 mm, a velocity discontinuity occurs and the curve slope increases.



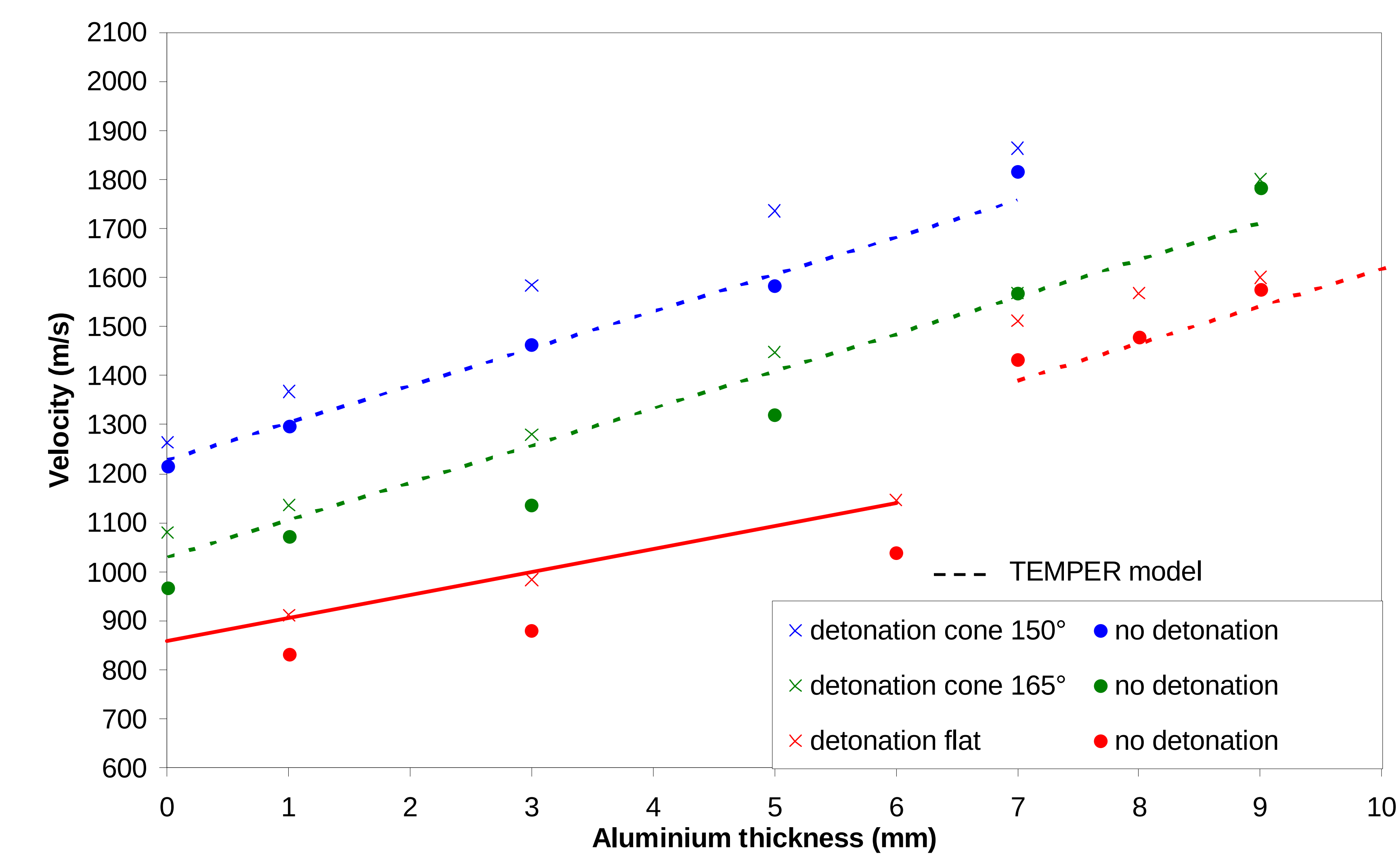
- Model extended up to 10 mm
- Further validations required above 10 mm

Extension of Jacobs-Roslund Model to Conical-Ended Fragment

- Major interest to model the NATO fragment
- Modelling based on experiments carried out by Dr Haskins with various cone angles
- Approach detailed in the paper

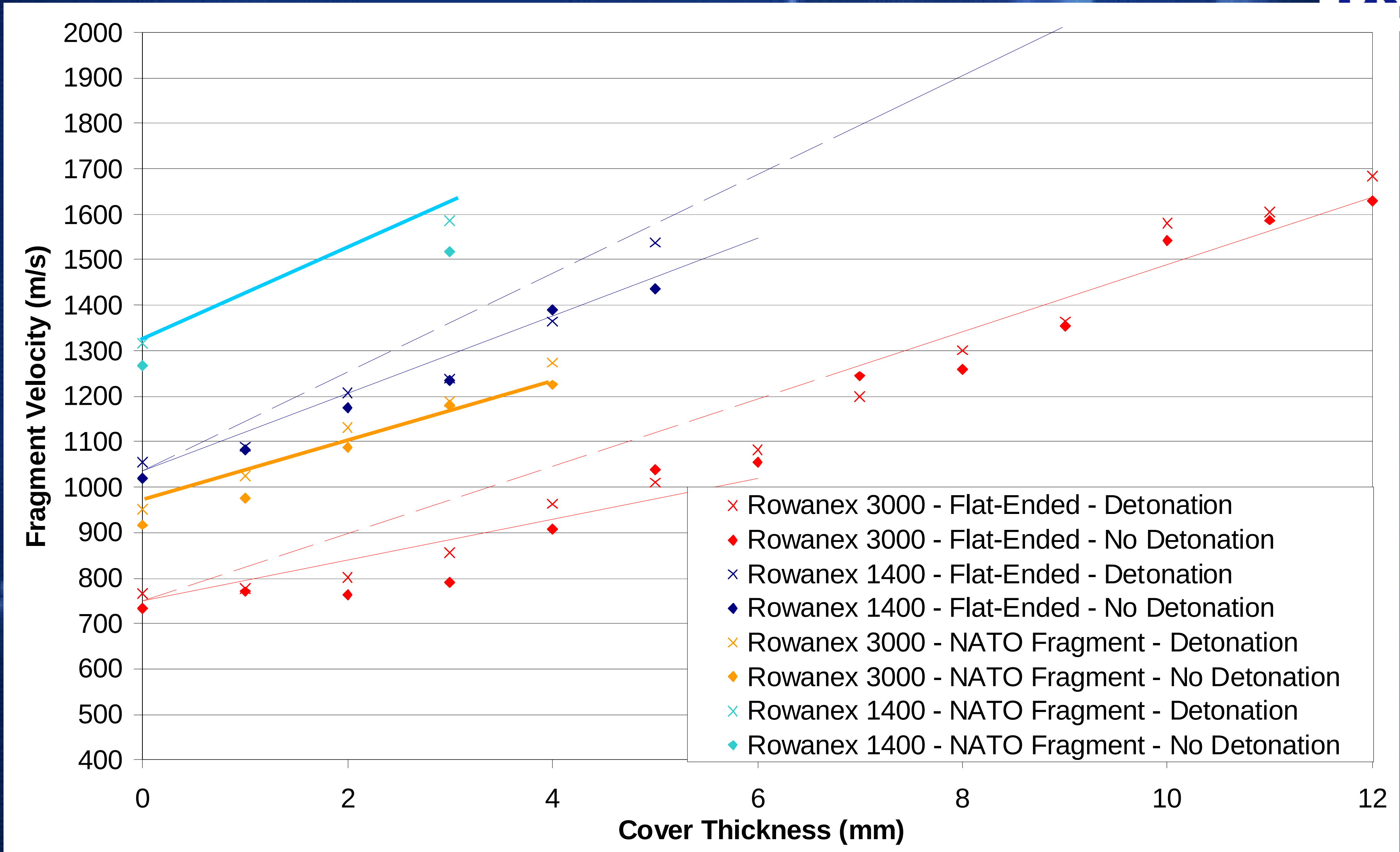
Extension of Jacobs-Roslund Model to Conical-Ended Fragment

- **Validation with two cone angles 165° and 150°**



Extension of Jacobs-Roslund Model to Conical-Ended Fragment

- **Validation with NATO fragment**



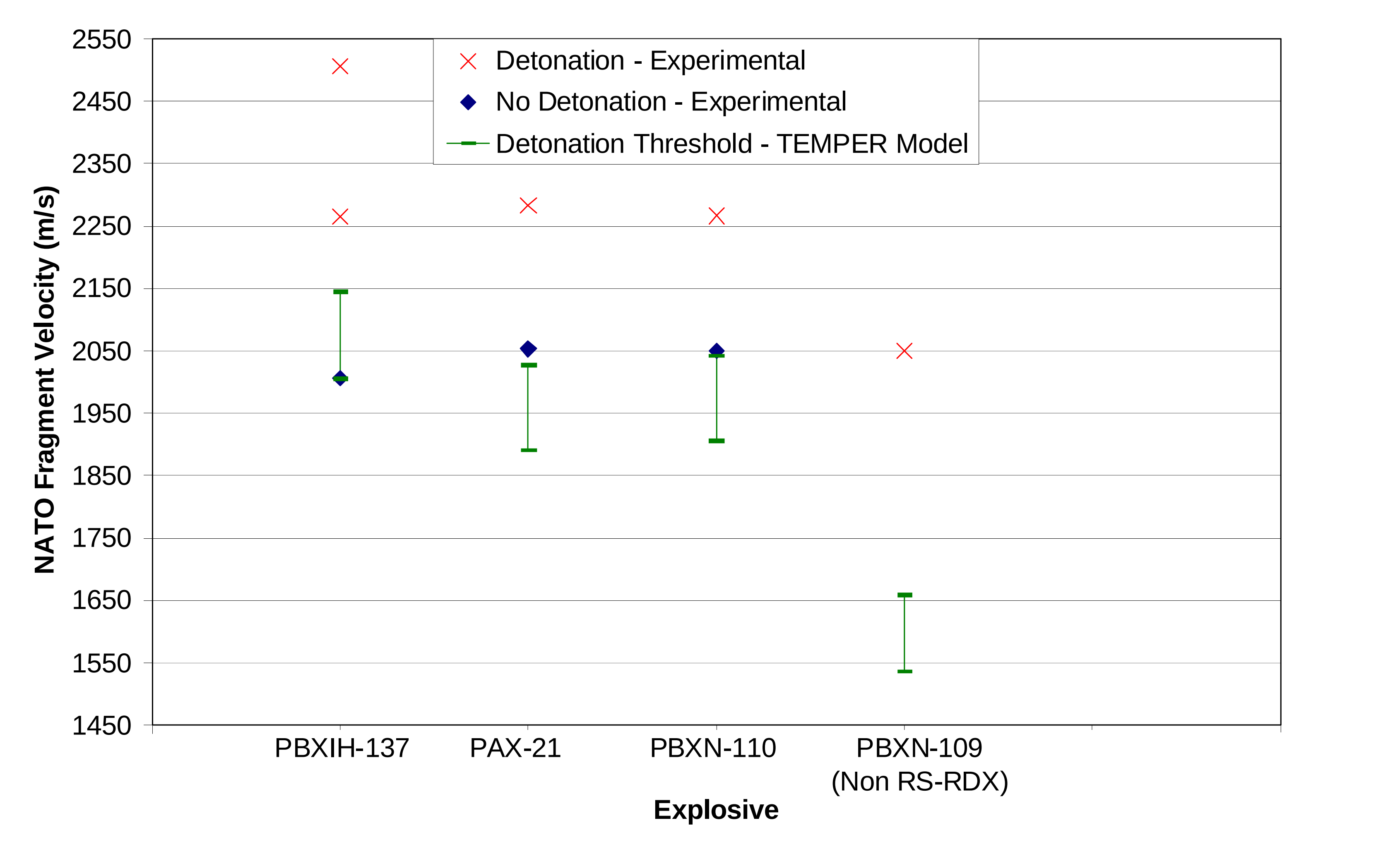
Application example

- **Work presented at IMEMTS conference in 2007 about an IM improvement program for HYDRA-70 Rocket warheads**
- **Four explosive candidates down selected and tested against NATO fragment in a warhead mock-up**
- **Warhead mock-up with a steel case**
  - ϕ 76 mm and 5.1 mm thick

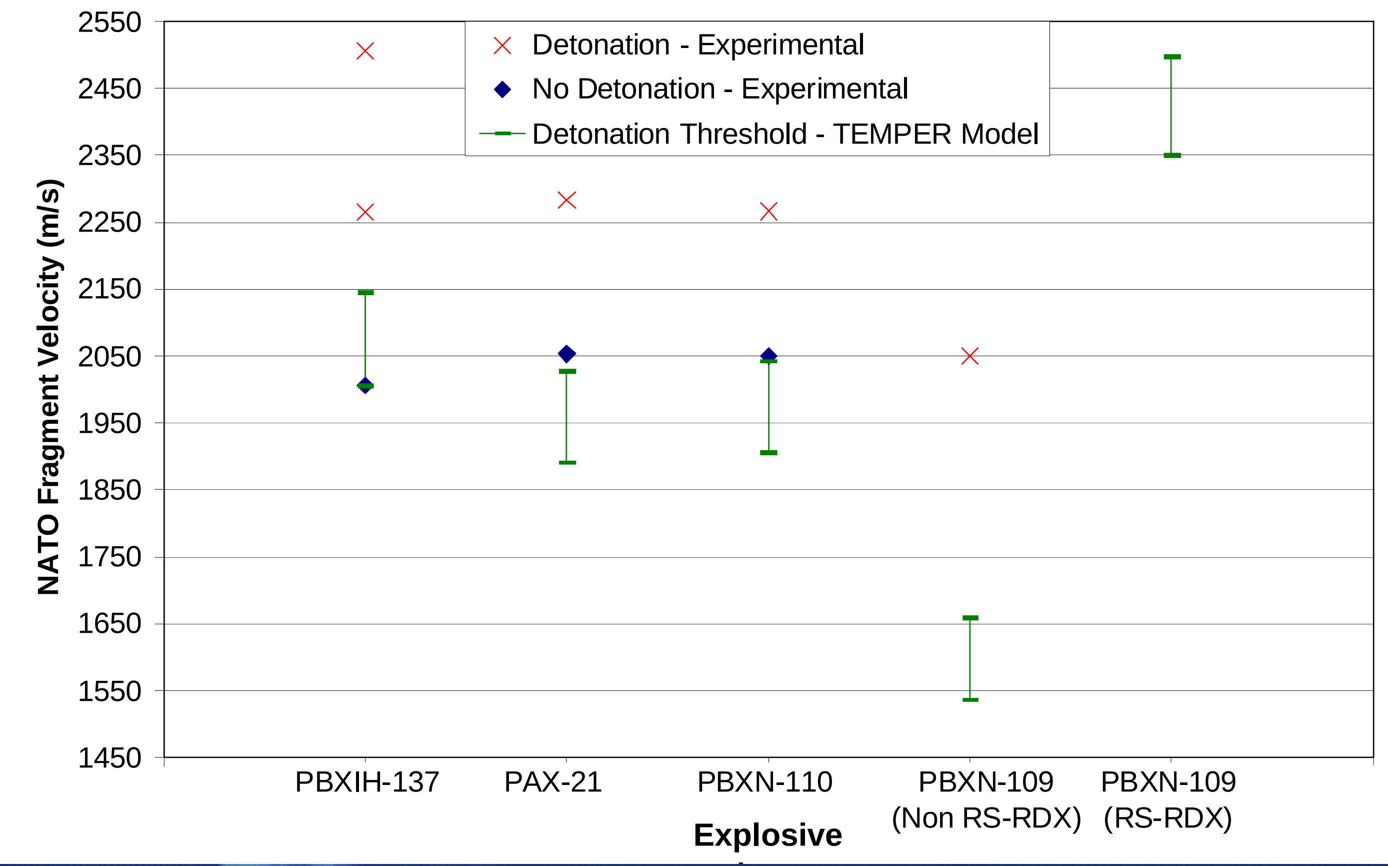
Explosive	Composition	NOL-LSGT Gap Test Threshold (GPa)
PBXIH-137	82% RDX - 18% Binder	4
PAX-21	34% DNAN - 30% AP - 36% RDX	3.62
PBXN-110	88% HMX - 12% HTPB	3.67
PBXN-109 (Non RS-RDX)	64% RDX - 20% Aluminium - 16% HTPB	2.2

Application example

- **Tests carried out at three impact velocities:**
  - 2050, 2250 and 2500 m/s



Application example



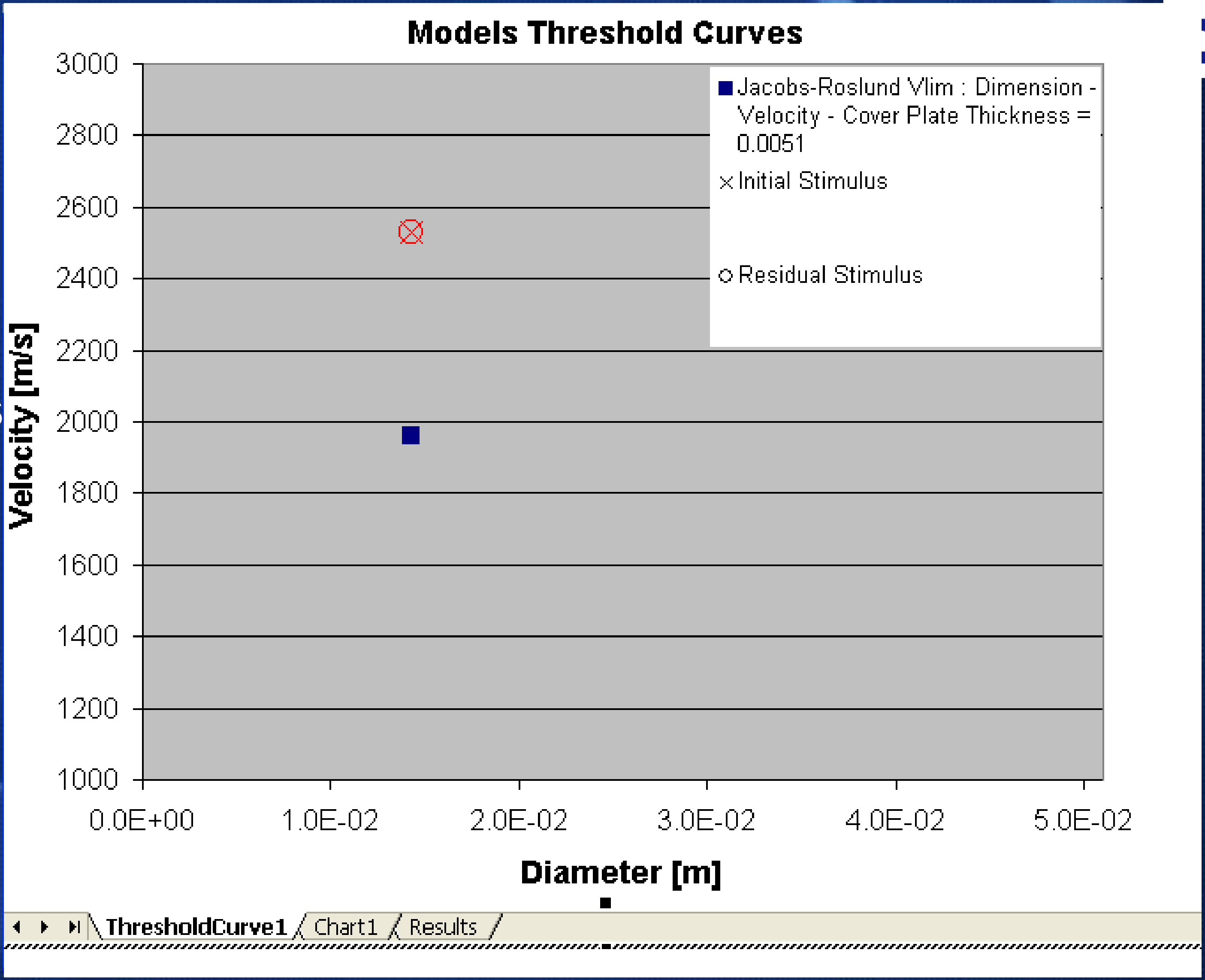
- **Calculated threshold velocities slightly below experimental results but very good estimation as it is only based on LSGT shock sensitivity**
- **Benefit of PBXN-109 with reduced sensitivity RDX other conventional RDX**

Application example

Main window

Parameters window

Results window



Conclusions

- **New features available in next TEMPER version**
- **Reasonable agreement obtained with existing experimental results**
  - Validation going on
- **A training session will be organized on Thursday afternoon and you can join**

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