The Application of Critical Perforation Analysis (CPA) to Military Personal Armour Research and Evaluation

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Background

CPA was developed by:

- RMCS – Royal Military College of Science
- MPS – Metropolitan Police Service
- DC R&PS

This presentation will:

- Outline the method
- Describe the current status of development
    - Focusing on shoot pack testing carried out at DC R&PS

Background

When testing with bullets (not fragments) the usual method of assessment is a pass/fail criteria

- No way of quantitatively assessing how close to failing the armour is (i.e. has it been over-engineered or will the next shot perforate?)
- Many test standards require only 6 shots on an armour assessment (although several armours will be tested for certification)

When testing with fragments the two values of interest are the V_{50} and V_0

- V_{50} - velocity at which the estimated probability of perforation is 0.5 for a given projectile and target. Three perforations and three non-perforations of the pack are used to calculate the arithmetic mean (V_{50}).
- V_0 - highest velocity at which the estimated probability of perforation is 0 for a given projectile and target.

What is CPA

CPA is a ballistic test method tool giving a quantitative value of performance

- Determines V_{50} using all projectiles
- Determines Standard Deviation (SD)
- Using the V_{50} and SD to estimate the $V_{0.1}$ (estimated as an approximation to V_0)
- Determines F_{perf} – frequency of perforation (between 40 to 60% is acceptable)

Theory of CPA

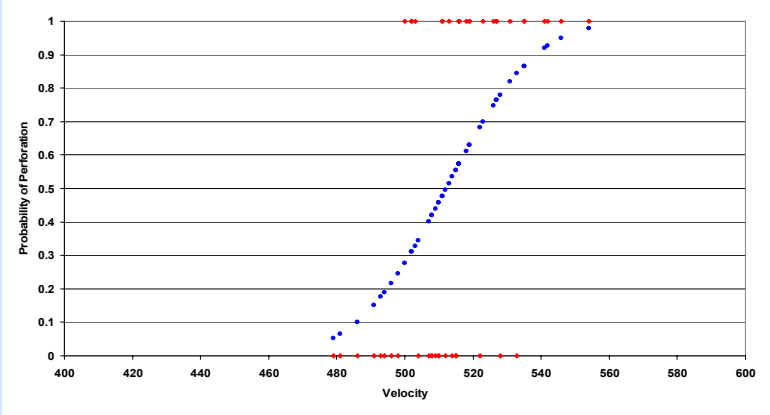
Projectile either will or will not perforate the target

Probability of perforation can be plotted as:

- 0 = non-perforation or
- 1 = perforation
- Can be plotted against velocity

If 'least squares' method is applied:

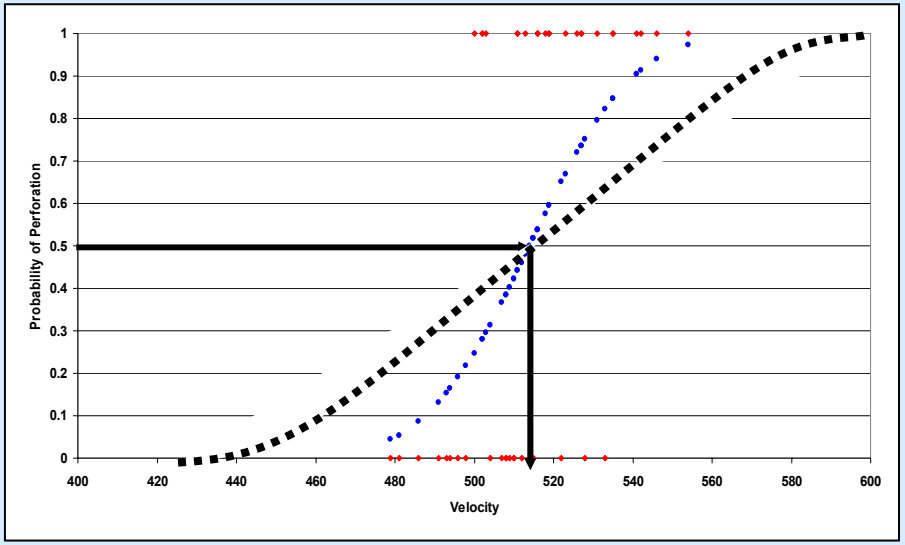
- produce a Cumulative Normal Distribution Curve (CND)



Theory of CPA

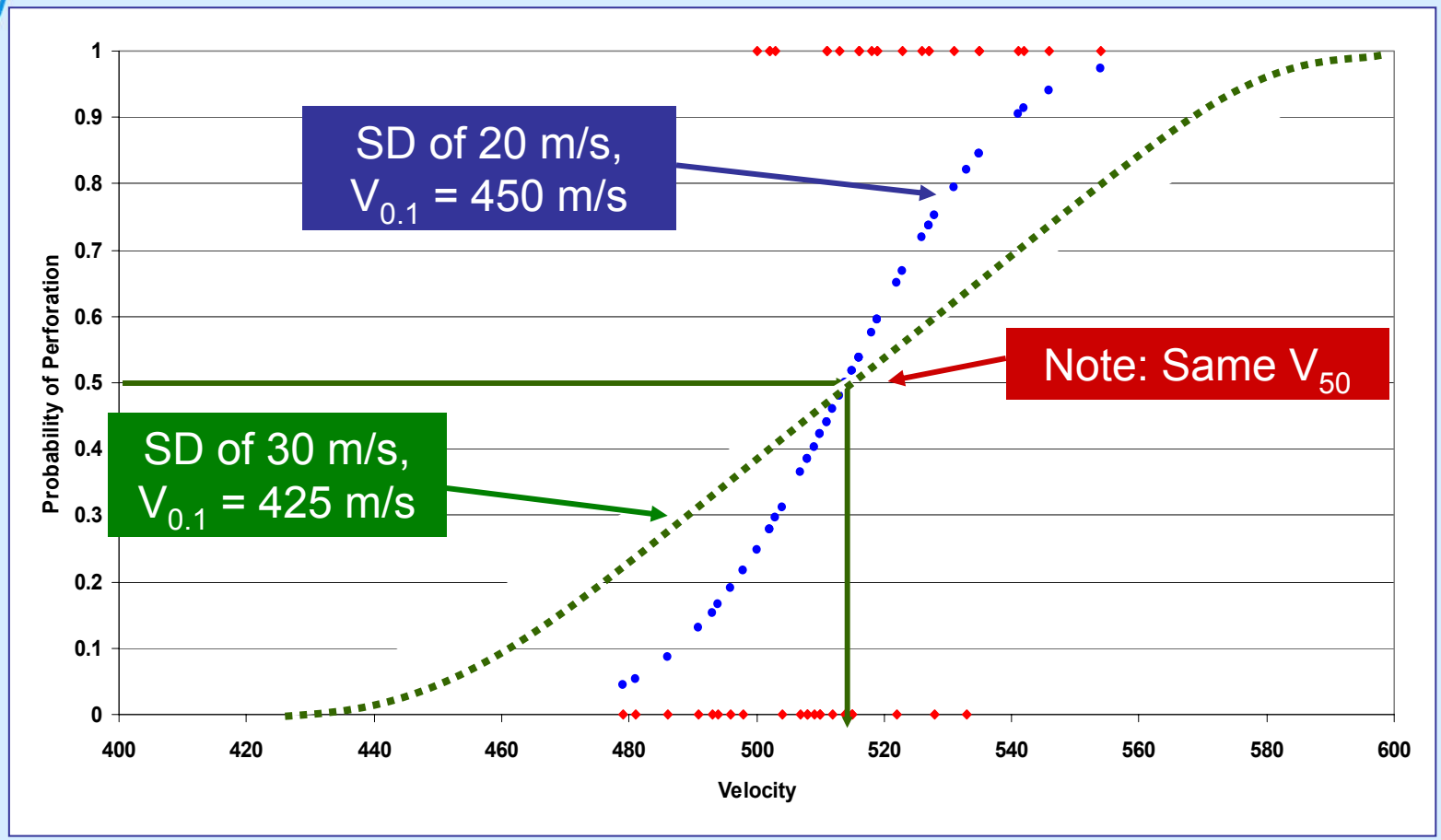
Using the CND curve we can assume that:

- Probability of 0.5 equates to the V_{50}
- There is an associated standard deviation (SD)
- The V_0 can be estimated, more accurately the $V_{0.1}$ can be estimated as an approximation to V_0
  - It is assumed to be 3x SD below the V_{50}

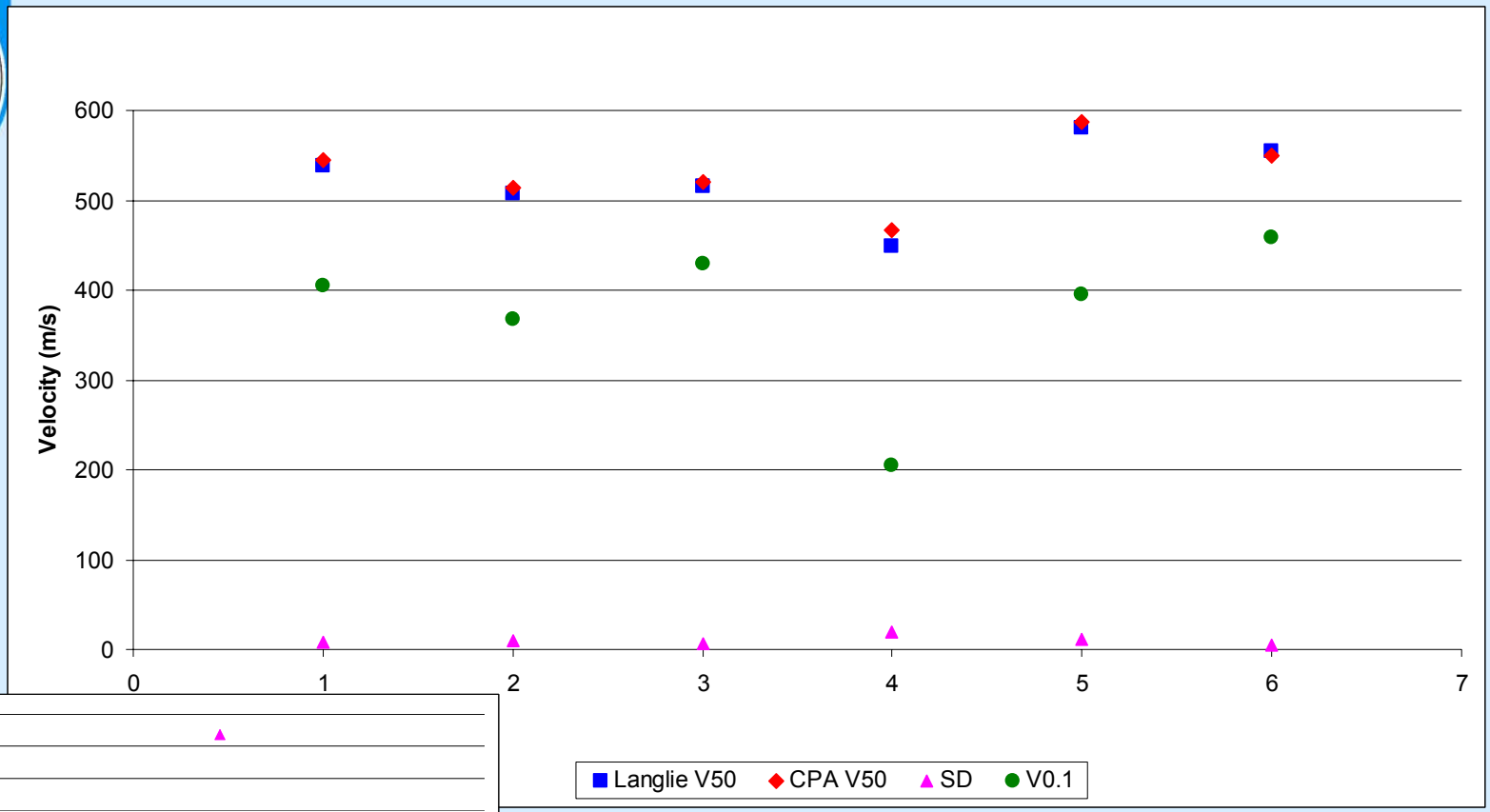


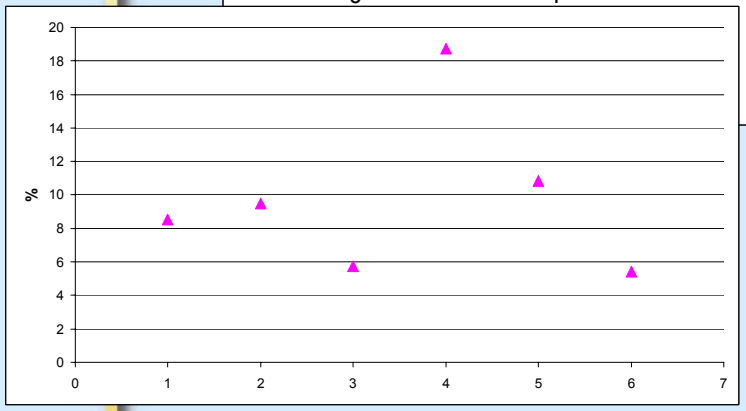
Theory of CPA

V_{50} in isolation does not give all the information



Comparison of Results

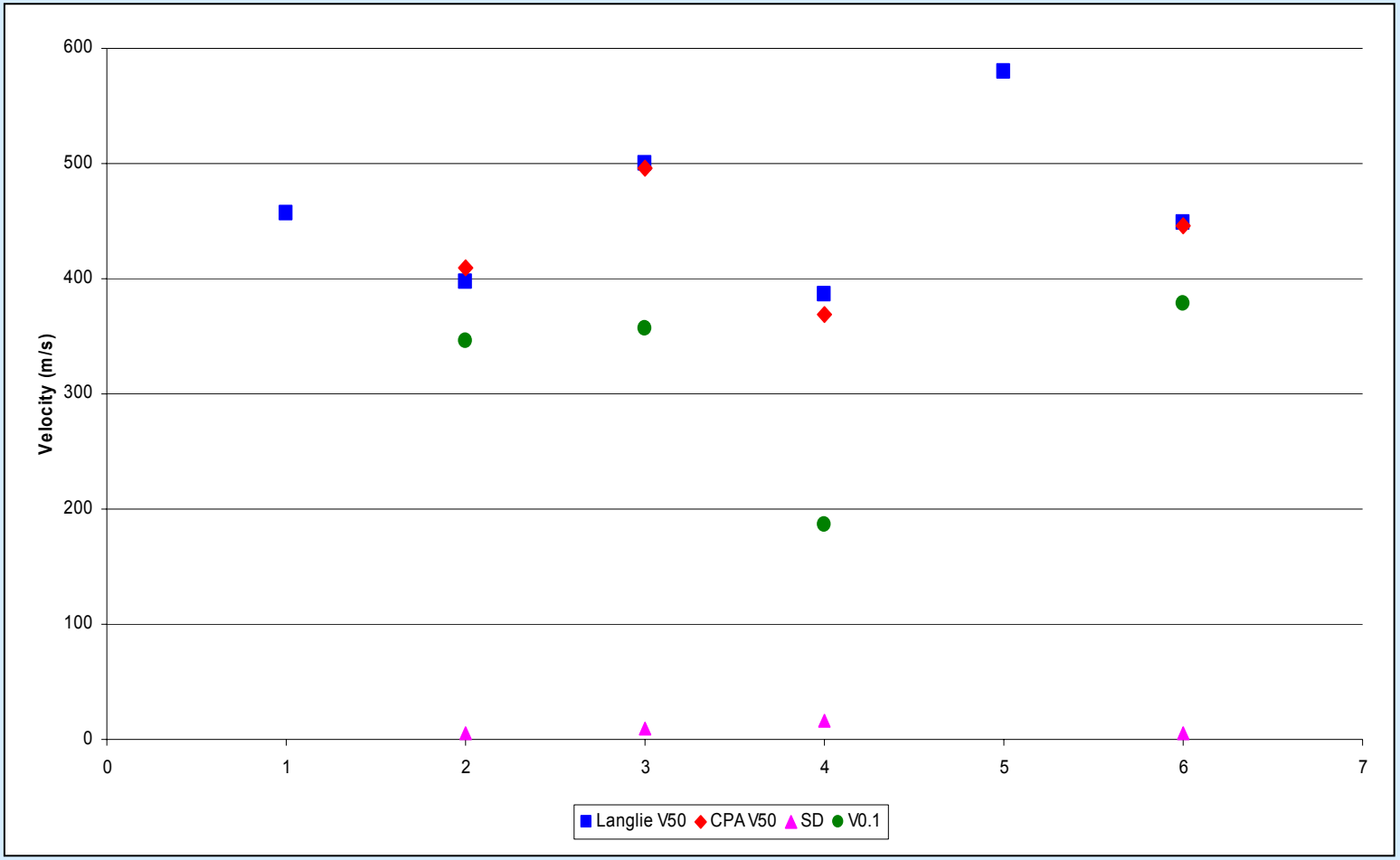




Comparison of Results

Textile	No of Shots	V_{50} (m/s)		CPA		
		STANAG 2920	CPA	SD (%)	Est $V_{0.1}$ (m/s)	F_{perf} (%)
1	50	538	544	8.52	405	46
2	49	508	514	9.50	368	45
3	61	515	520	5.75	430	49
4	52	448	467	18.72	205	37
5	42	580	586	10.84	396	43
6	41	554	549	5.44	459	59

Comparison of Results



Comparison of Results

Textile	No of Shots	V_{50} (m/s)		CPA		
		STANAG 2920	CPA	SD (%)	Est $V_{0.1}$ (m/s)	F_{perf} (%)
1	44	457	No Solution			
2	35	397	409	5.14	346	51
3	37	500	496	9.39	356	54
4	44	387	369	16.50	186	64
5	41		No Solution			
6	39	448	446	5.08	378	54

Further Work

- Validation of estimated $V_{0.1}$ predictions
- Improve user-friendliness
- Define testing procedures
- Validation for hard armour targets
  - Taking into account possible bi-modal distribution
- Confidence levels

Contact Details

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