



# Sound levels and exposures from a high-velocity rifle

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# Sound levels and exposures from a rifle

## Project rationale

Two discrete events may be audible to someone downrange, in or close to the line of fire, from a high-velocity rifle:

- The shockwave as the bullet passes supersonically (“crack”)
- The sound of the muzzle blast (“thump”)

The time delay between the “crack” and the “thump” can indicate the distance of the firer. The delay increases with distance.

To the side of, and behind the firer, only the muzzle blast is distinguishable, levels are high, and hearing protection is needed.



# Sound levels and exposures from a rifle

## Project outline

A research project into the localization of small arms fire on an outdoor range was being undertaken for the MOD. That project, not described here, required binaural sound recordings.

An opportunity therefore arose to make conventional noise measurements, in parallel with that project.

Noise levels produced by a 5.56 mm SA80 high velocity rifle were measured:

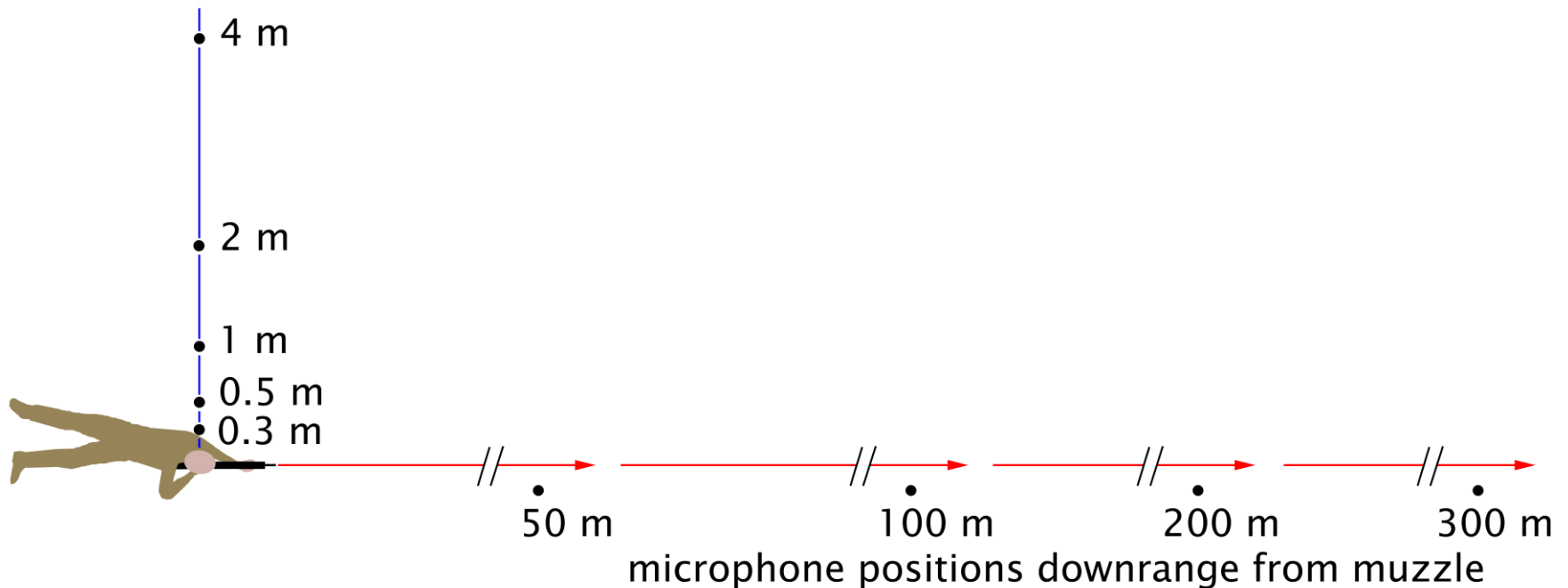
- Downrange, at 50, 100, 200 and 300 metres
- To the side of the firer, at 0.3, 0.5, 1, 2, 4, 8, 16 and 32 metres



# Sound levels and exposures from a rifle

Measurement positions: Downrange and to the side of the firer

Additional measurement positions at 8 m, 16 m and 32 m from side of firer's head not shown on plan







# Sound levels and exposures from a rifle

The outdoor firing range at Warminster



# Sound levels and exposures from a rifle

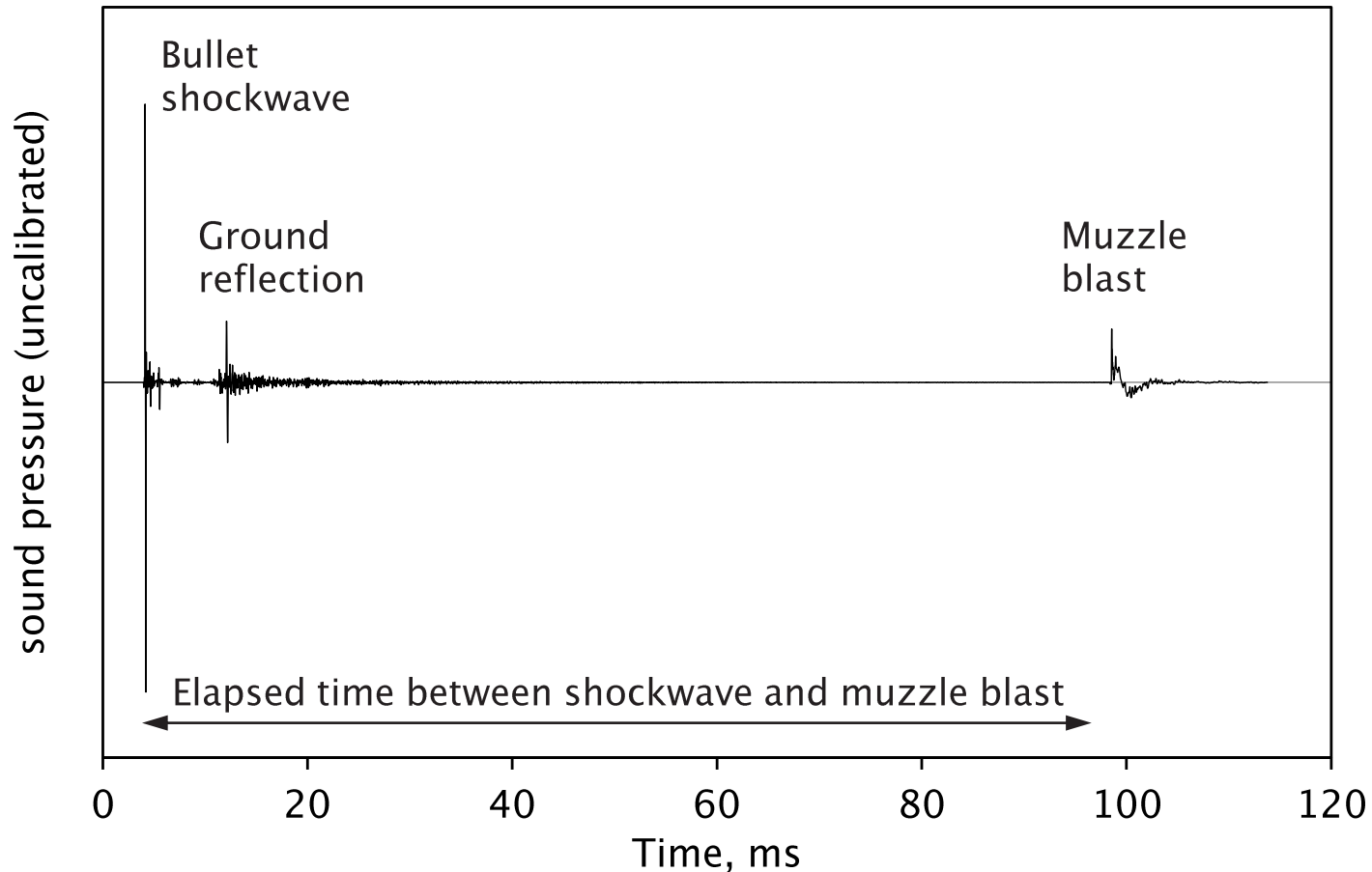
View from behind the firer; the rifle was aimed 30 cm above the manikin





# Sound levels and exposures from a rifle

Waveform recorded at 50 m downrange





# Sound levels and exposures from a rifle

## Example sounds

Two rounds each at 50 m, 100 m, 200 m and 300 m



As recorded, preserving the dynamic range



Amplified by 30 dB and clipped to illustrate the delay between 'crack' and 'thump'

Distance, m	Time delay between the 'crack' and the 'thump', ms
50	94
100	185
200	350
300	507



# Sound levels and exposures from a rifle

Time delay between 'crack' and 'thump' and bullet speed

Distance, m	Time delay between the 'crack' and the 'thump', mean (S.D.) ms	Time taken for bullet to travel the distance ms	Average speed of the bullet over the distance m/s
50	94.1 (0.3)	53.7	930
100	184.5 (0.9)	111.2	899
200	350.1 (2.0)	241.3	829
300	507.1 (3.5)	379.9	790

Estimated muzzle velocity: ~948 m/s

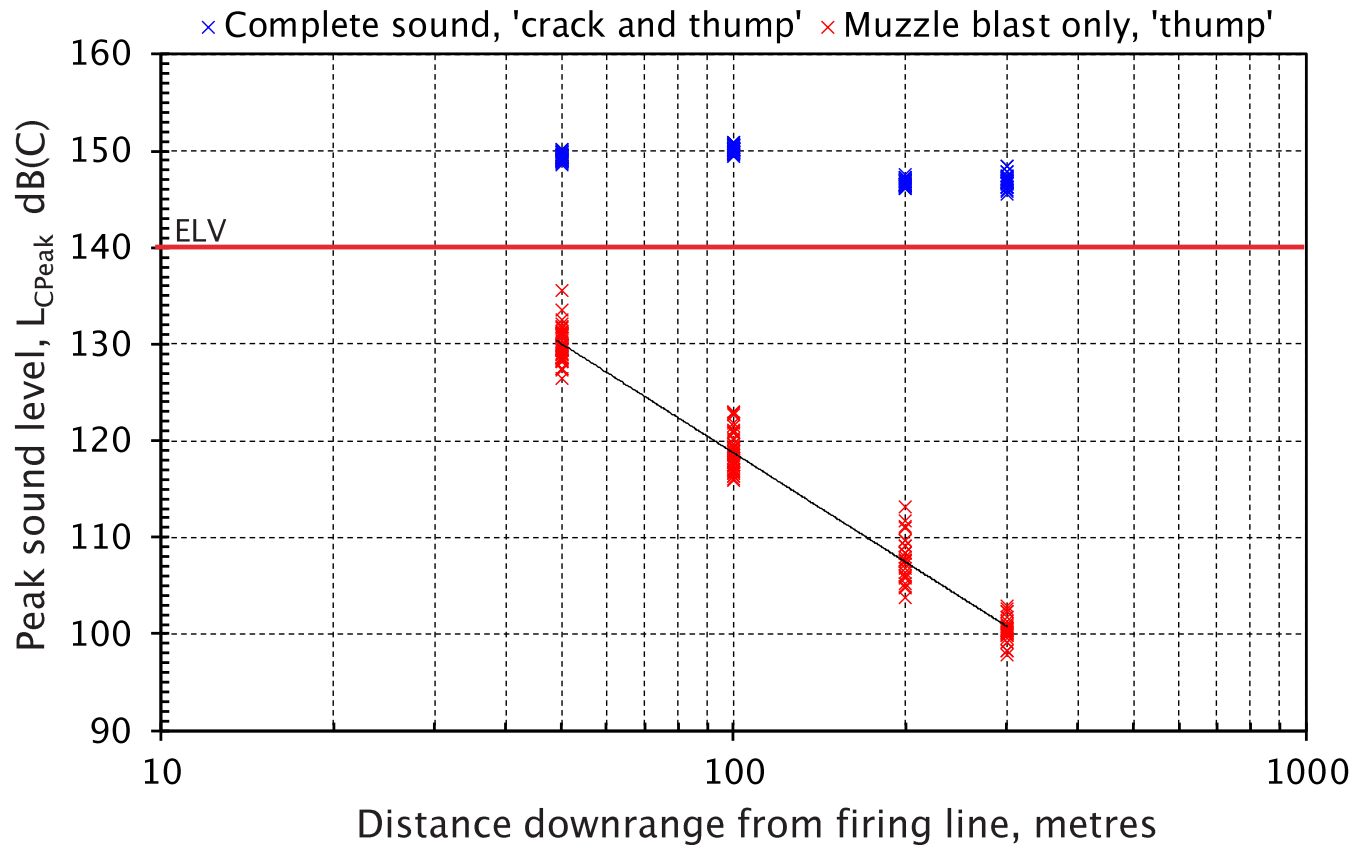
Estimated bullet speed at 300 m downrange: ~678 m/s

(Average temperature 12 °C, speed of sound 338 m/s)



# Sound levels and exposures from a rifle

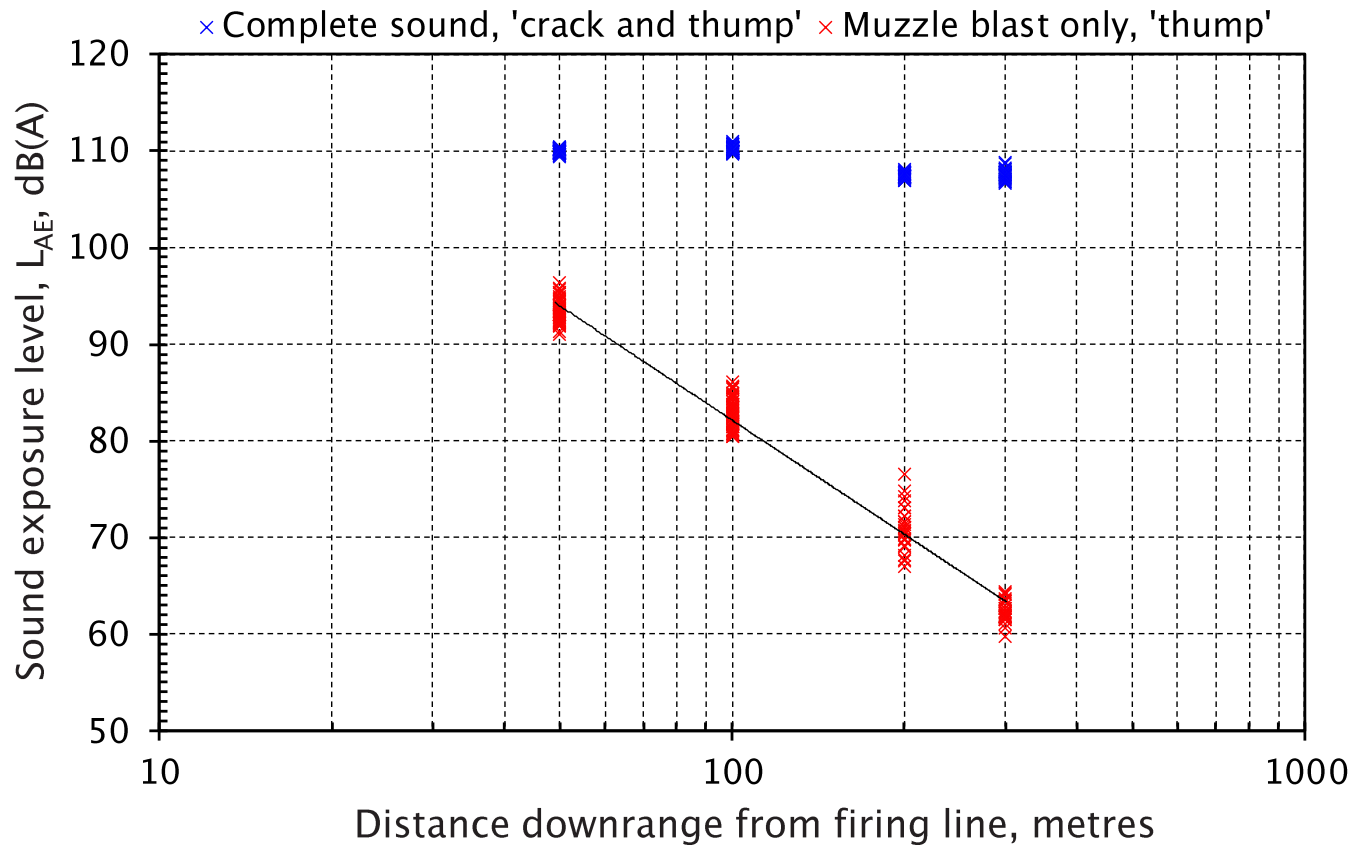
Peak sound levels downrange,  $L_{Cpeak}$





# Sound levels and exposures from a rifle

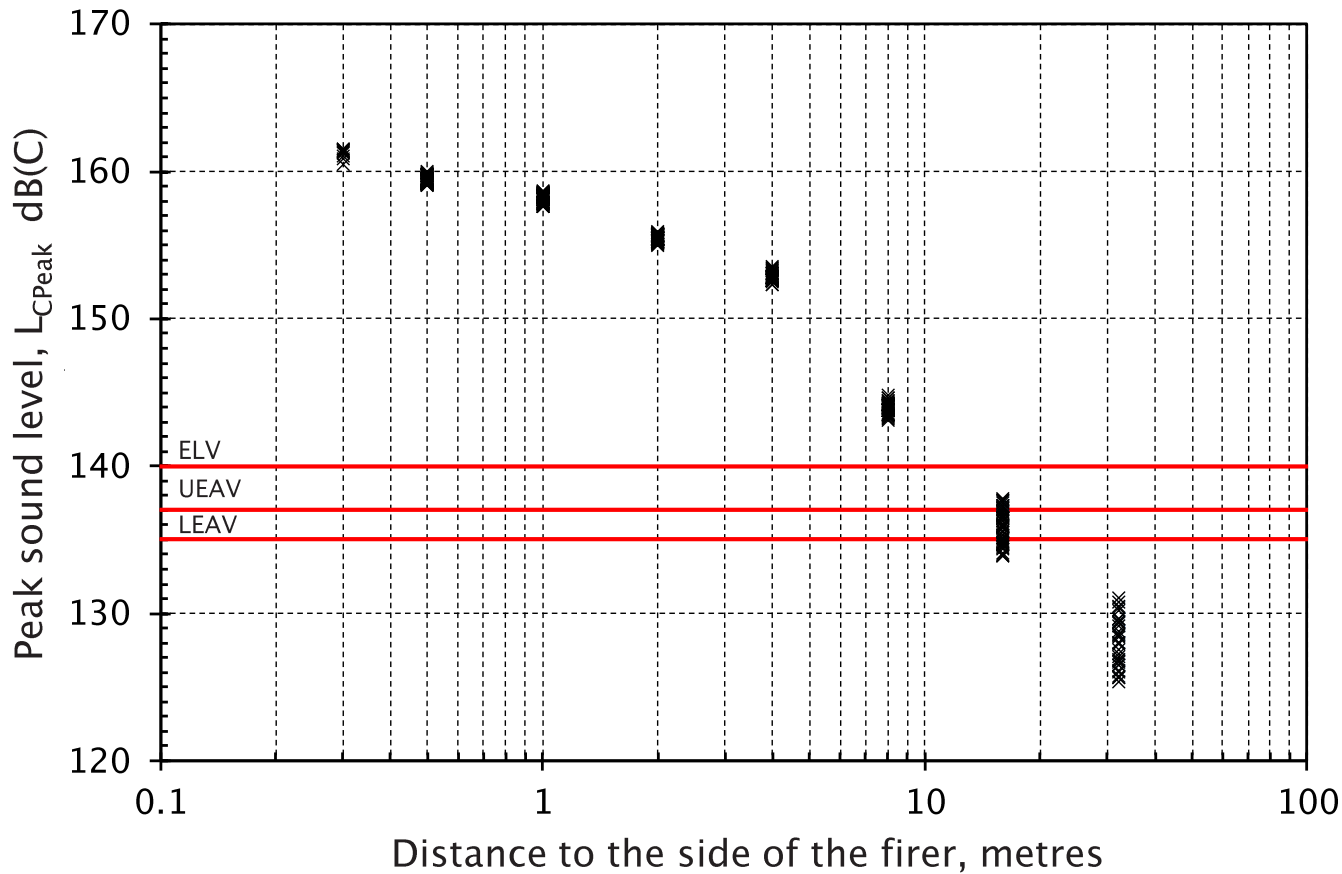
Sound exposure levels downrange,  $L_{AE}$  (single rounds)





# Sound levels and exposures from a rifle

Peak sound levels to the side,  $L_{Cpeak}$

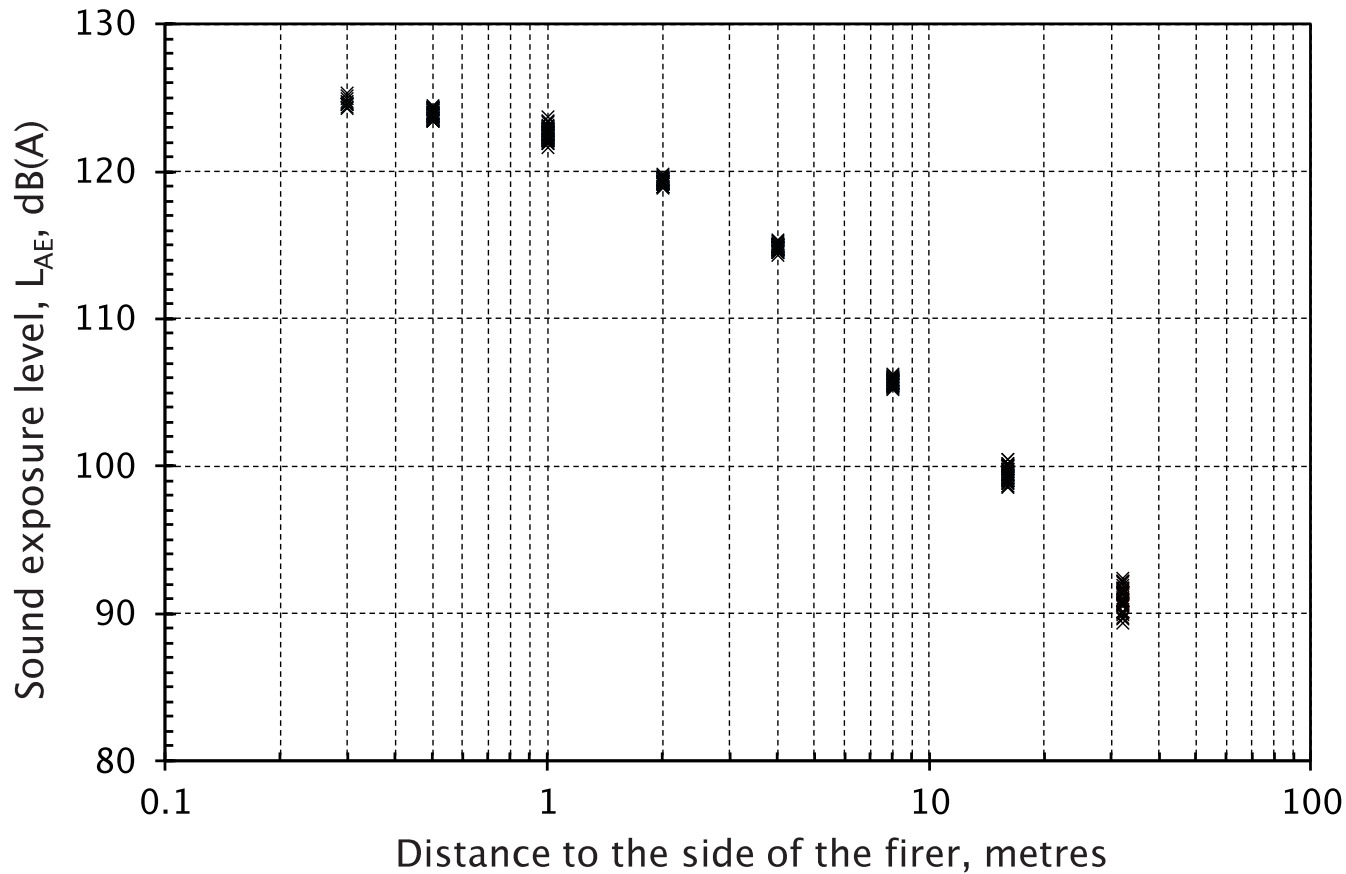






# Sound levels and exposures from a rifle

Sound exposure levels to the side,  $L_{AE}$





# Sound levels and exposures from a rifle

## Conclusions

- Downrange:
  - Peak sound levels, caused by the bullet shockwave, exceeded 145 dB(C), even at 300 m downrange
  - Strictly speaking, hearing protection should be worn by an individual in the line of fire, though the risk of being shot would be a more immediate concern
  - Hearing protection with talk-through (sound restoration plug or muff based headsets) is available and would provide adequate protection downrange

» continued



# Sound levels and exposures from a rifle

## Conclusions, continued

- To the side in the firing line, or behind the firing line:
  - Peak levels exceeded 135 dB(C) at ~25 m from the firer
  - Hearing protection must be provided and is recommended if closer than 25 m to the nearest person firing
  - Peak levels exceeded 137 dB(C) at ~20 m from the firer
  - Hearing protection should be compulsory if closer than 20 m to the nearest person firing
  - At 20 m from the firer, an observer's daily personal noise exposure will reach 85 dB(A)  $L_{EP,d}$  after 1440 rounds per day
  - The requirement for hearing protection is likely to be determined by the peak sound level of individual rounds rather than by the daily personal noise exposure or the number of rounds



# Sound levels and exposures from a rifle

## Further information

A longer version of this presentation was published as

G S Paddan and M C Lower; Factors affecting sound exposure from firing an SA80 high-velocity rifle *Applied Acoustics*, **109**, (2016), 61–68.

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# YOUR QUESTIONS

