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# Keep Your Distance!
# Safe Separation and No-arm Distance for Fuzes

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**PARARI 2026**



# Outline

- Defence Policy requirement for No-arm Distance and Safe Separation Distance (SSD)
- Difference between No-arm Distance and SSD
- Determination of No-arm Distance WRT fuze arming processes
- SSD WRT EO damage mechanisms
- Relationship of SSD to Risk
- Regulatory Expectations
- Compliance assessment with Defence Policy requirements

# Safety, Arming & Functioning Systems

- AKA "**SAF Systems**":

  *A system that provides safety, arming and functioning for munitions* (Australian Defence Glossary)

- Various SAF system sub-categories; for munition payloads (e.g. warheads) referred to as "**fuzing systems**" or "**fuzes**"

**Safety**
Preventing initiation when undesired

**Arming**
Transitioning to a condition where initiation is possible – **only** when safe to do so

**Functioning**
At the desired time and place, upon receipt of valid signal / command / stimulus

# Defence Policy Requirement

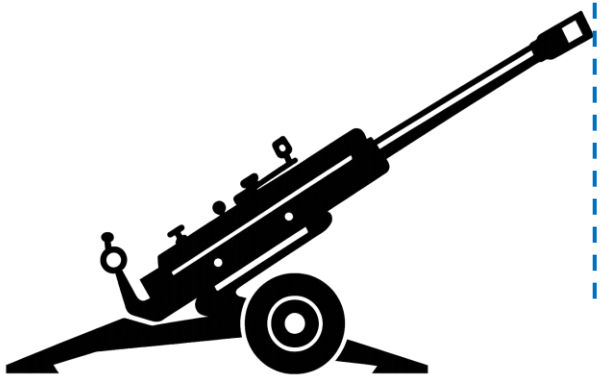
- **DEOP 102 Ch 9D** requires SAF systems to be designed and assessed IAW applicable standards.
- For warhead fuzing systems this is **AOP-4187**
- Para 3.1.3.h requires:

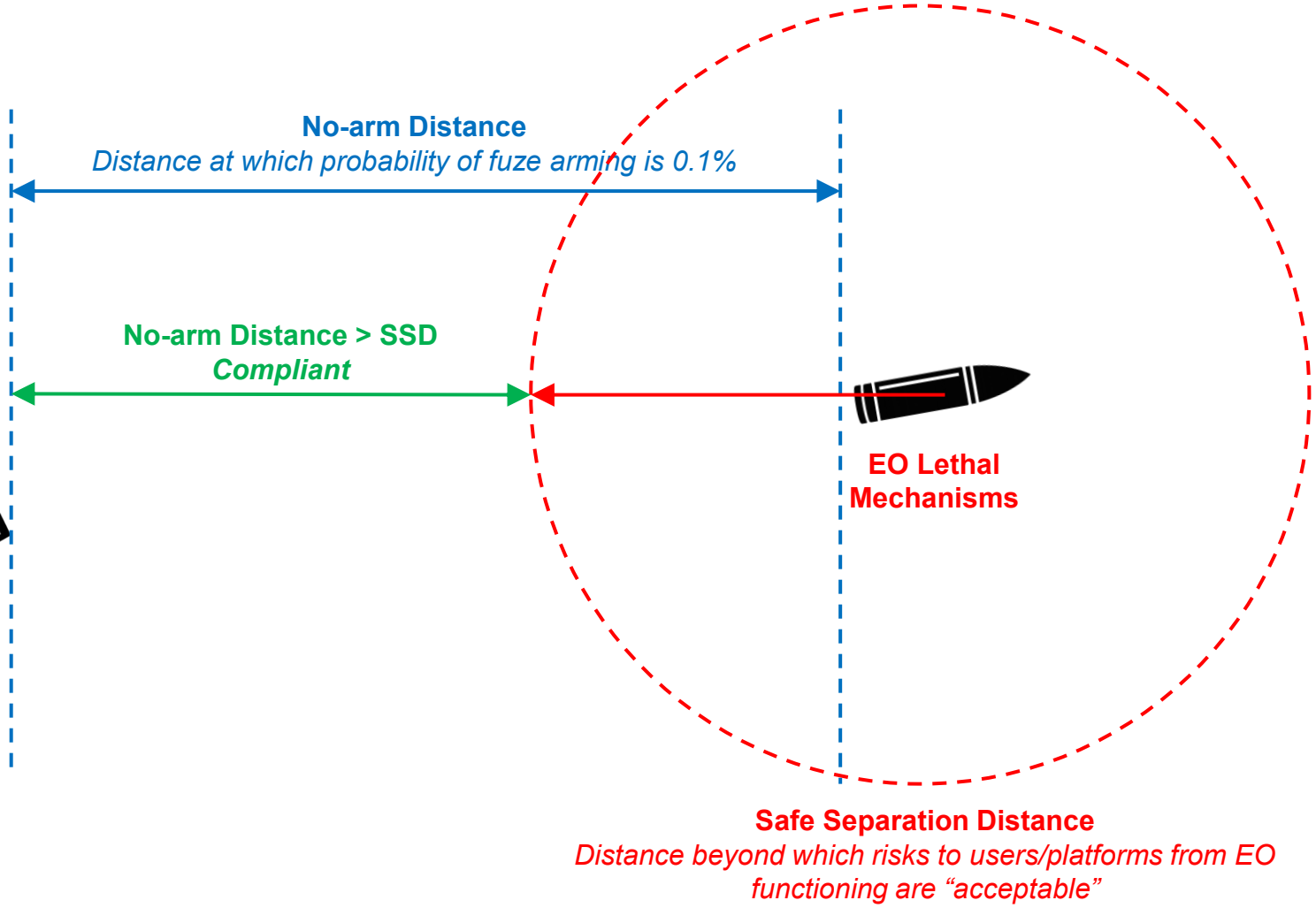
*At least one of the independent safety features of the fuzing system shall **prevent arming** after launch or deployment until the specified **safe separation distance** or equivalent arming delay has been achieved.*



# Defence Policy Requirement

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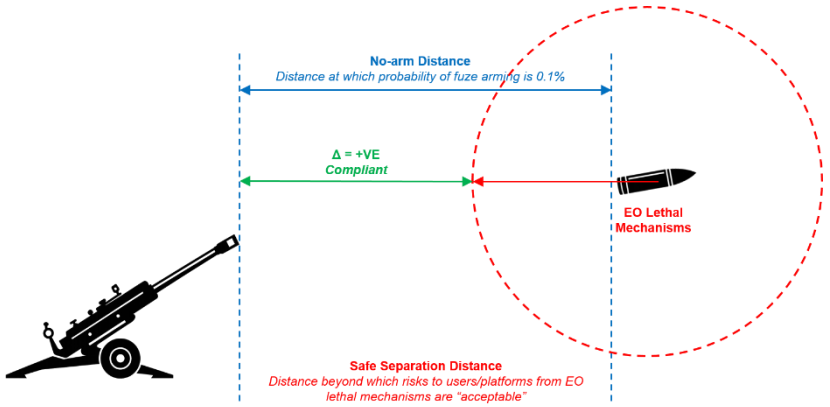




# Defence Policy Requirement

- Why is this important?
  - There is a (small) chance that the fuze will function immediately upon arming (e.g. design flaws, manufacturing defects, environmental exposure, **valid target**)
  - Requiring No-arm Distance > SSD reduces risk of damage / injury to platform / user
  - **Global best practice in fuzing system design – strong weighting towards what is "reasonably practicable" to do**

*At least one of the independent safety features of the fuzing system shall **prevent arming** after launch or deployment until the specified **safe separation distance** or equivalent arming delay has been achieved.*



# No-arm Distance vs SSD

Accurate definition essential to prevent exposure of users to elevated levels of risk – **not the same thing and often confused!**

**No-arm Distance**

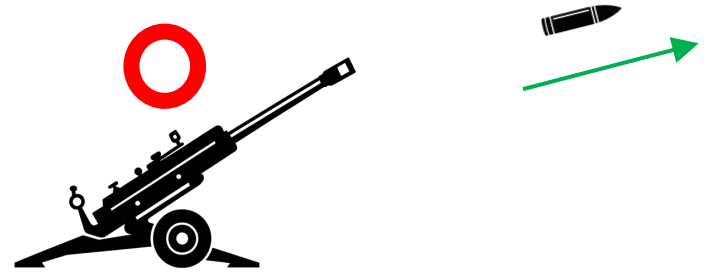
- Relates to arming processes of **fuze**
- Function of relative motion of EO system and associated environments

**SSD**

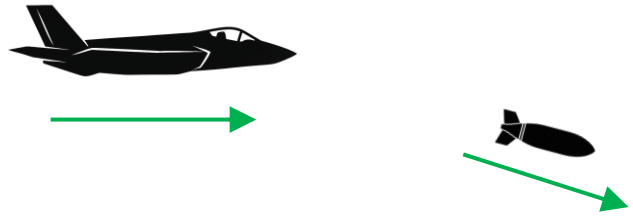
- Relates to damage mechanisms of **warhead**
- Function of damage mechanisms & their scaling with distance
- Some influence from use context

# No-arm Distance – Fuze Arming Process

- EO moves relative to a fixed point of launch / deployment



- Both EO and user / platform move



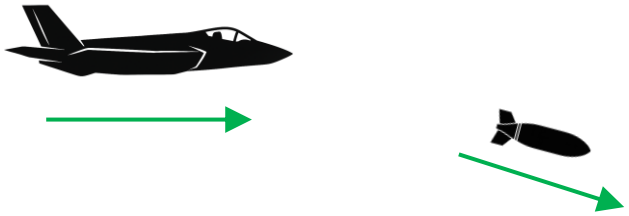
- User / platform moves relative to stationary EO



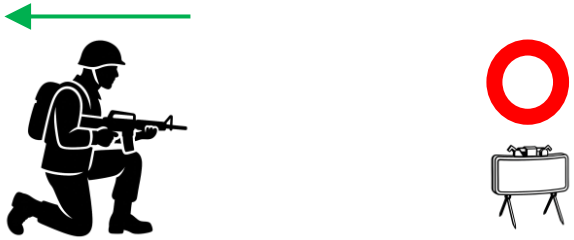
# No-arm Distance – Fuze Arming Process



- Deterministic / non-reversible
- Distance = time-integral of *a* or *v*
- High confidence in no-arm distance using e.g. timers, escapements etc.



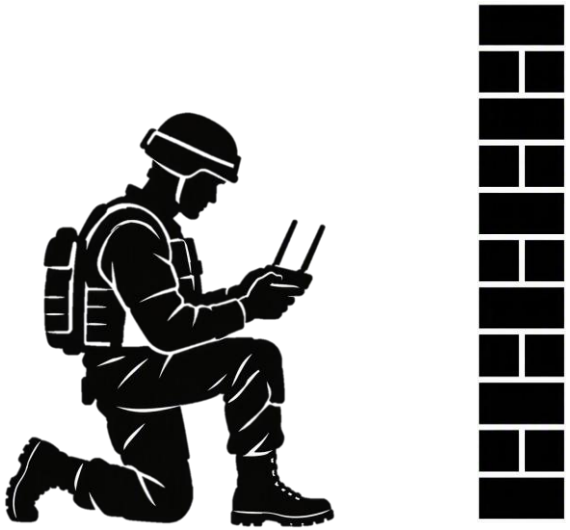
- Location / distance of EO can be determined, but…
- …must account for relative platform motion
- No-arm distance has partial dependence on user action



- No environments available
- Time-based delays, command arming
- No-arm distance entirely reliant on user action

# No-arm Distance – Drone-based Munitions





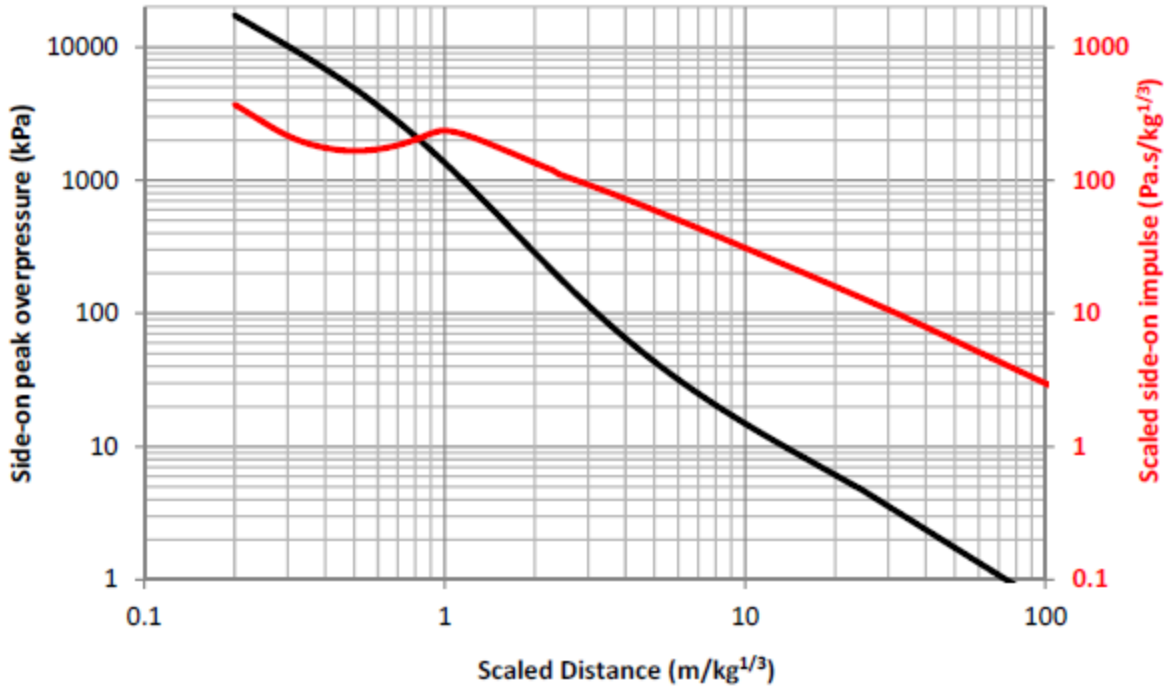
- Flight characteristics (i.e. slow, agile, hovering flight etc.) ➔ difficult to derive straight-line distance from environmental stimuli (e.g. acceleration, airspeed etc.)
- User controlled / influenced flight ➔ system can violate No-arm Distance
  - May be a desirable trait (e.g. sheltered targets)
- Transition to armed state controlled by e.g.:
  - Command arming
  - Geolocation
  - User influence of flight path

# SSD – EO Damage Mechanisms

- Blast
- Fragmentation
- Thermal effects:
  - Heat flux (i.e. infrared radiation)
  - Jet flame
  - (NB for design mode initiation of EO, typically a minor contribution to damage mechanisms)

# SSD – EO Damage Mechanisms

- Blast:
  - Pressure wave travelling radially outwards from point of detonation
  - Initial magnitude a factor of NEQ, explosive type, casing material/thickness/dimensions, etc.
  - Peak overpressure scales with distance according to 1/3 power law



# SSD – EO Damage Mechanisms

- Blast:
  - Example injury levels:

- For a given initial magnitude of blast:

$$\text{Injury} \propto 1/\text{distance}$$

| Injury | kPa | psi |
|---|---|---|
| Temp. hearing loss | 1.3 | 0.2 |
| Eardrum rupture – threshold | 13 | 2 |
| Eardrum rupture – 50% | 34 | 5 |
| Internal injuries – threshold | 48 | 7 |
| Lung haemorrhage – threshold | 82 | 12 |
| Lung haemorrhage – 50% fatality | 137 | 20 |
| Lung haemorrhage – 99% fatality | 206 | 30 |
| Immediate fatality | 482 | 70 |

DEOP 101

# SSD – EO Damage Mechanisms

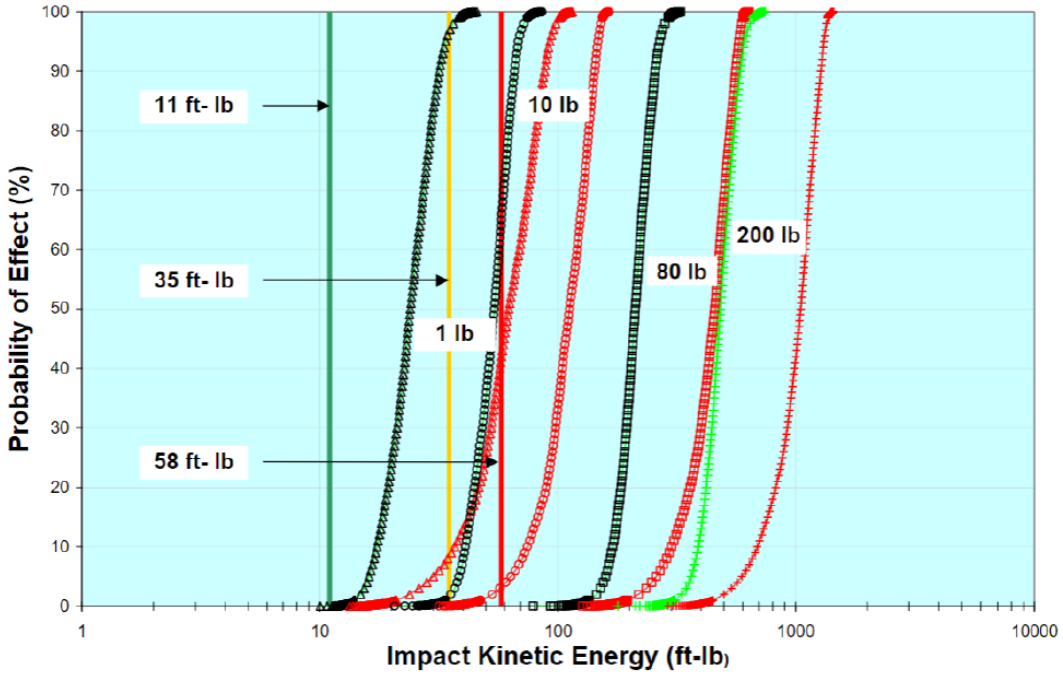
- Fragmentation characteristics (quantity, size, shape, dimensions, velocity, max range, density, spatial distribution) depend on:
  - Explosive type
  - Explosive quantity
  - Case material
  - Case thickness
  - Case construction (naturally fragmenting, pre-scored, discrete)
  - Orientation
  - Etc…

# SSD – EO Damage Mechanisms

- Fragmentation injury a function of:
  - Kinetic energy (decreases with distance due to aerodynamic drag)
  - Size/shape/mass (penetrating injury vs. blunt-force trauma)
  - Location of strike (head, neck, thorax, abdomen, limbs)
  - Age / size / health of person

- Fragmentation density decreases with distance ➔ probability of strike decreases

**red line** = lethality
**green line** = casualty

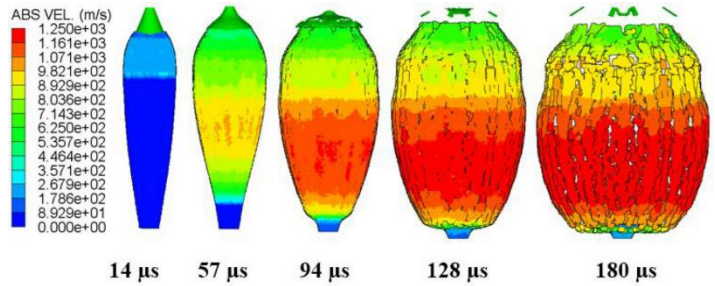



Haber and der Avanesian (2000)

# SSD – EO Damage Mechanisms

- Need to quantify magnitude of effect as a function of distance for a given warhead
- Approaches:
  - Empirical models
    - Mott / Gurney / Taylor
    - KE variation w/ distance; density
  - Simulation
  - Trials
    - Direct measurement of blast
    - Video / radar measurement of fragment velocity & trajectory
    - Fragment capture ➔ mass distribution

$$v_o = \sqrt{2E}\left[\frac{\left(W/W_c\right)}{1+0.5\left(W/W_c\right)}\right]^{1/2}$$




Elshenawy *et al.*. (2023)



# SSD – Relationship to Risk

- SSD is defined based on “acceptability” of risks from EO damage mechanisms
- SSD is defined based on minimisation of risks SFARP

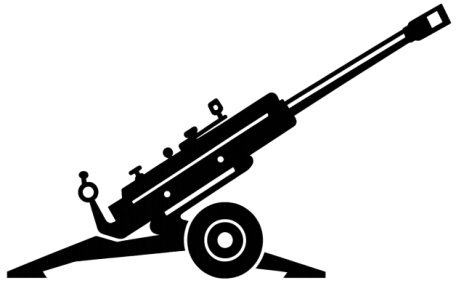
**Risk = Probability X Consequence**

$P_{(Initiation)} = 1$

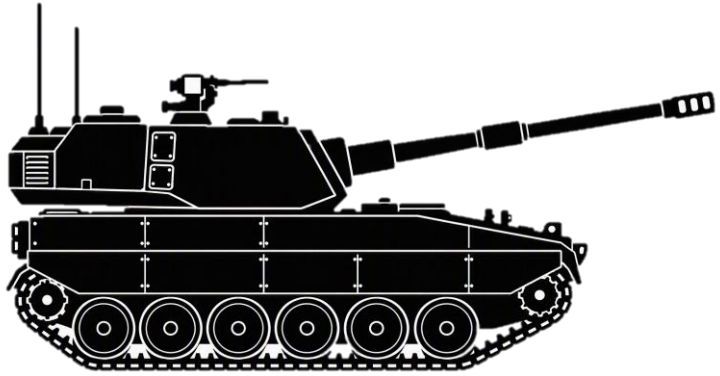
Injury = *f* (d, warhead)

Injury = *f* (context)

# SSD – Relationship to Risk



- Same ammo = same damage mechanisms at a given distance = same SSD…?
- Contextual factor: protection from platform:
  - M777 – no protection
  - AS-9 – armoured – fragment attenuation – reduced SSD

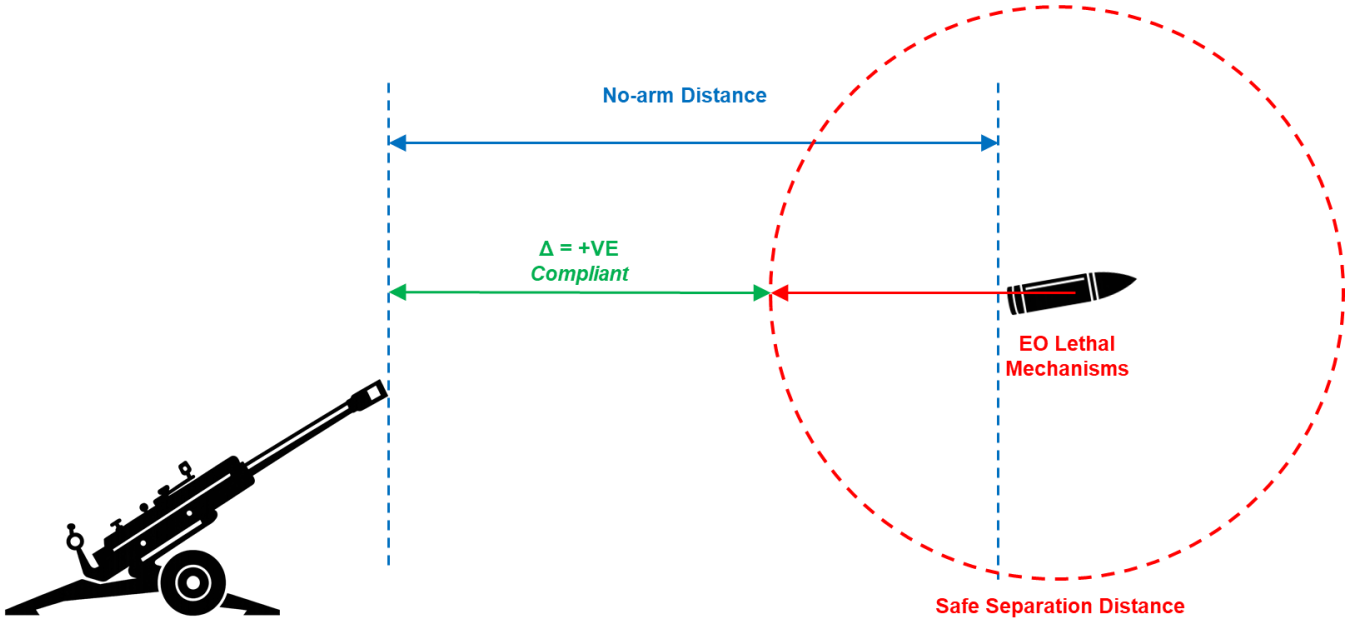


- For a given magnitude of EO damage mechanism, SSD is context dependent
- Also consider “risk appetite” (e.g. training vs. operations)
- **Only Capability Operator can confirm EO damage mechanism risks reduced SFARP ➔ SSD**

# Regulatory Expectations

| Element | Responsible Parties |
|---|---|
| No-arm Distance:<br>• In metres<br>• Mechanisms for determination of relative distance<br>• For each configuration<br>• Probability (and confidence) stated and justified | Project<br>(with input from Capability Operator, and higher-level integrating platforms and systems – e.g. where no-arm is dependent on platform or user motion) |
| EO Damage Mechanisms<br>• Blast, frag, (thermal effects)<br>• Scaling with distance<br>• For each configuration | Project<br>(with input from Defence centres of expertise where necessary) |
| SSD<br>• In metres<br>• Quantified in terms of EO damage mechanisms at that distance | Capability Operator<br>(with input from Project and Defence centres of expertise) |

# Compliance Assessment

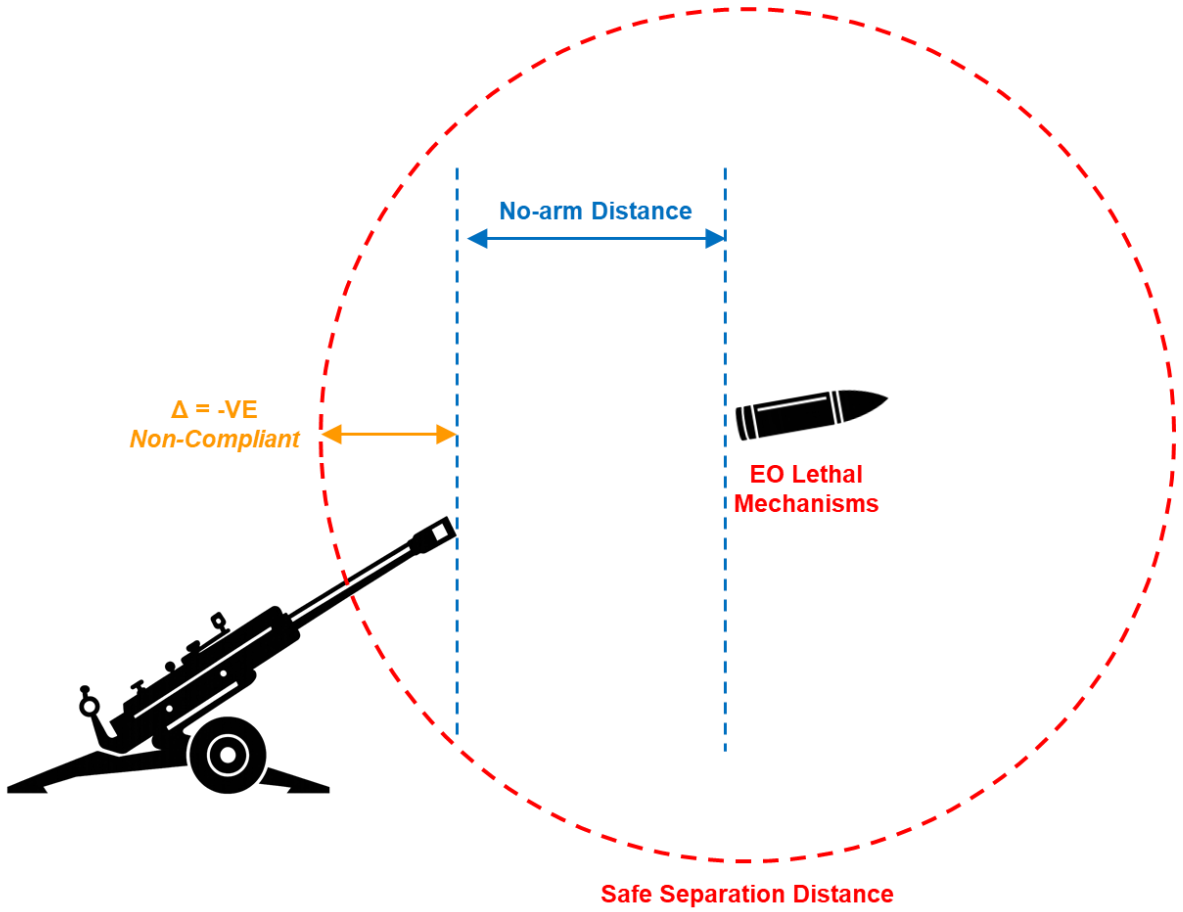



**Outcome 1:**

No-arm distance > SSD

Safe outcome achieved

# Compliance Assessment



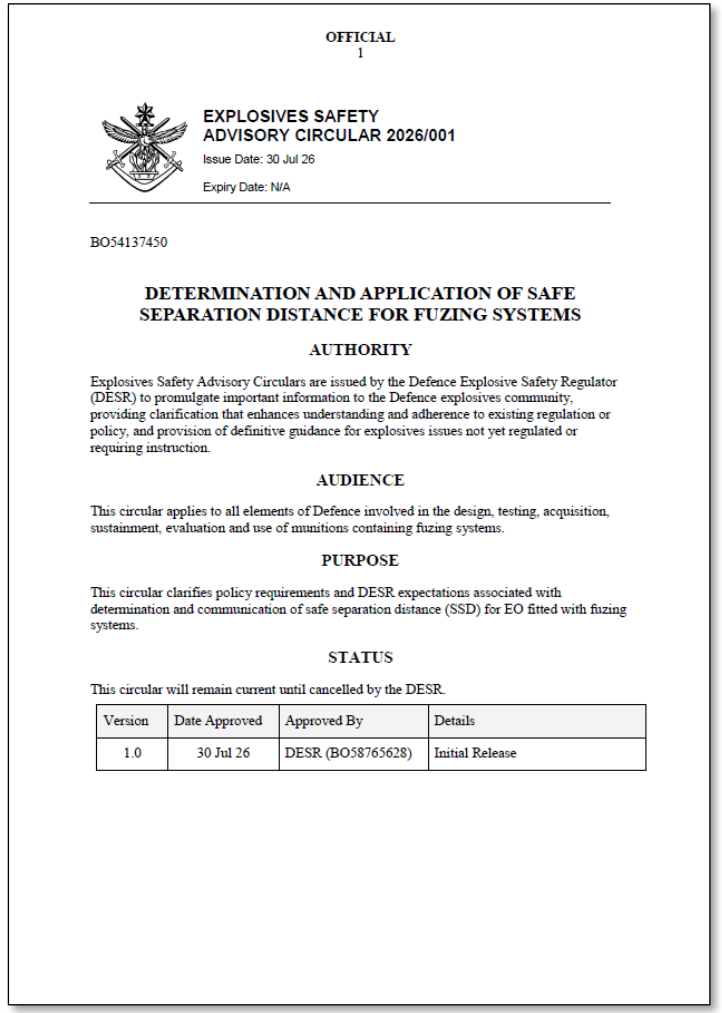

**Outcome 2:**

- No-arm distance < SSD; or
- No-arm distance not demonstrated to req'd probability; or
- No-arm distance entirely dependent on user action

Further work required to minimize risks SFARP

# Summary

- Defence policy in DEOP 102 Ch 9D
  - Implementation guidance in ESAC 2026/001
- No-arm Distance ≠ SSD
- Collegiate approach req'd to determine No-arm Distance, EO damage mechanisms & SSD
- No-arm distance **must be** greater than SSD
  - Otherwise further work req'd to reduce risks SFARP



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EXPLOSIVES SAFETY
ADVISORY CIRCULAR 2026/001
Issue Date: 30 Jul 26
Expiry Date: N/A

BO54137450

**DETERMINATION AND APPLICATION OF SAFE SEPARATION DISTANCE FOR FUZING SYSTEMS**

**AUTHORITY**

Explosives Safety Advisory Circulars are issued by the Defence Explosive Safety Regulator (DESR) to promulgate important information to the Defence explosives community, providing clarification that enhances understanding and adherence to existing regulation or policy, and provision of definitive guidance for explosives issues not yet regulated or requiring instruction.

**AUDIENCE**

This circular applies to all elements of Defence involved in the design, testing, acquisition, sustainment, evaluation and use of munitions containing fuzing systems.

**PURPOSE**

This circular clarifies policy requirements and DESR expectations associated with determination and communication of safe separation distance (SSD) for EO fitted with fuzing systems.

**STATUS**

This circular will remain current until cancelled by the DESR.

| Version | Date Approved | Approved By | Details |
|---|---|---|---|
| 1.0 | 30 Jul 26 | DESR (BO58765628) | Initial Release |

# References


- DEOP 101 *Department of Defence Explosives Regulations*
- DEOP 102 S*afety and Suitability for Service of Defence Explosive Ordnance* (Ed. 3 AL2 Feb 26)
- AOP-4187 *Fuzing Systems – Safety Design Requirements* (Ed. A V1 Jun 22)
- ESAC 2026/001 *Determination and Application of Safe Separation Distance for Fuzing Systems* (Jul 26)
- J. M. Haber and H. der Avanesian, *Human Vulnerability to Inert Debris,* 29th DDESB Symposium (2000)
- Elshenawy, t. *et al.*, *Experimental and Numerical Studies of Fragmentation Shells Filled with Advanced HMX-plastic Explosive Compared to Various Explosive Charges*, Braz. J. Chem. Eng. **40**, 481-492 (2023)