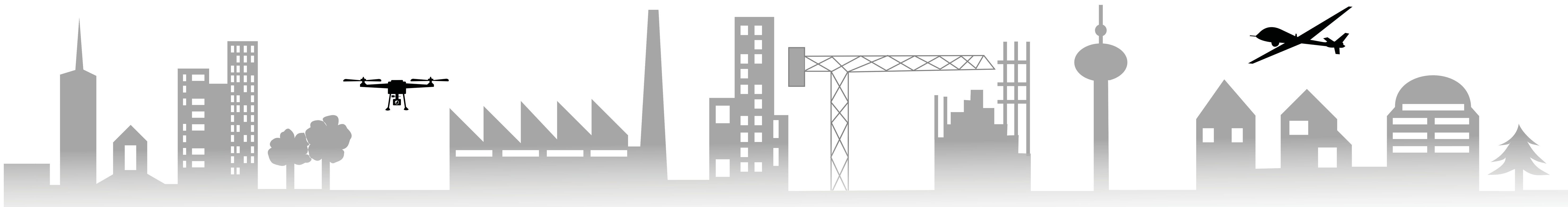

ERA OF DRONES: RISK MITIGATION FOR UNMANNED AIR VEHICLES MISSION PLANNING

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A growing problem

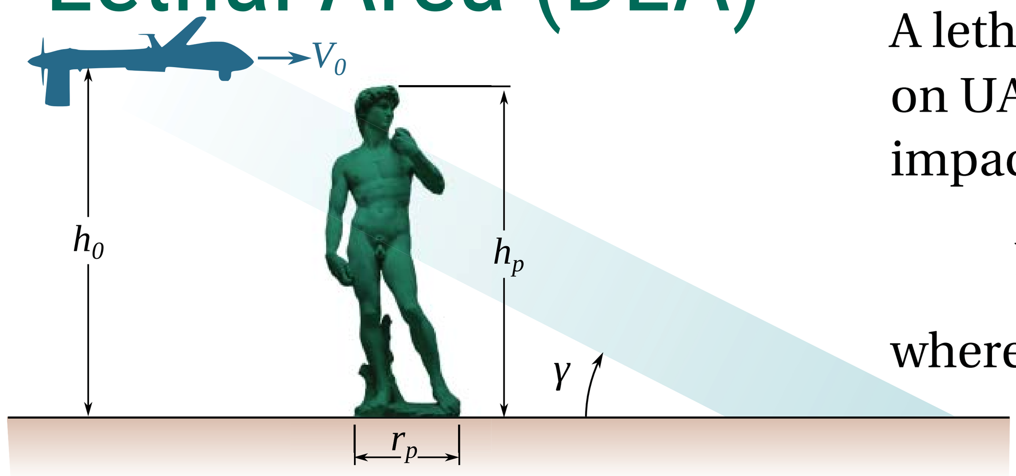
The use of drones (or Unmanned Air Vehicles, UAVs) is becoming common in normal life. Their presence is no longer restricted to military purposes and day to day are more visible. As both civil and military applications over inhabitated areas increase, also increase the risk of hazard for the population. It is then necessary to limit the risk of damage to people and sensible structures.

An incoming solution

The current normative proposes to evaluate and mitigate the risk of hazard to people based in the concept of lethal area. It assumes a **parabolic fall**, **absence of wind** and no fragmentation. However, the influence of navigation errors are at the moment not evaluated. The dispersion of the imact point due to these uncertainites may be larger than the lethal area.

Risk evaluation approaches

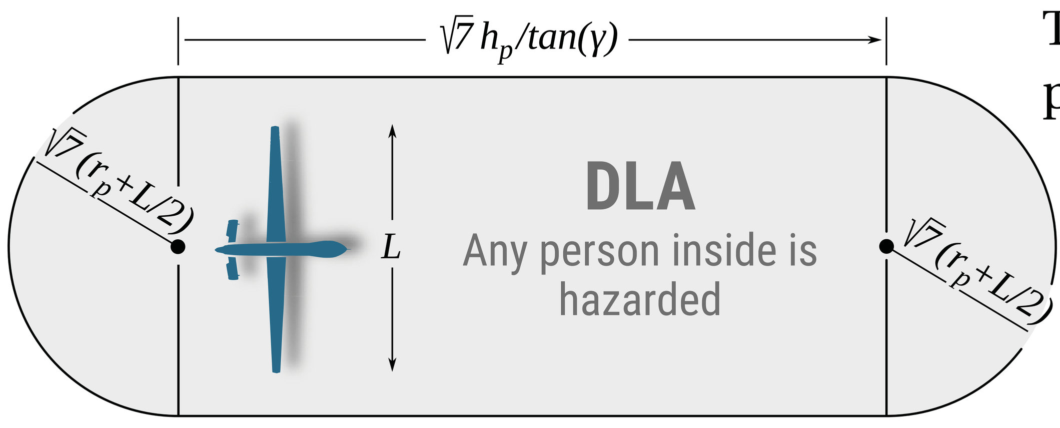
Deterministic Lethal Area (DLA)



A lethal area is defined based on UAV width ($\boldsymbol{L}$) and the impact angle (γ):

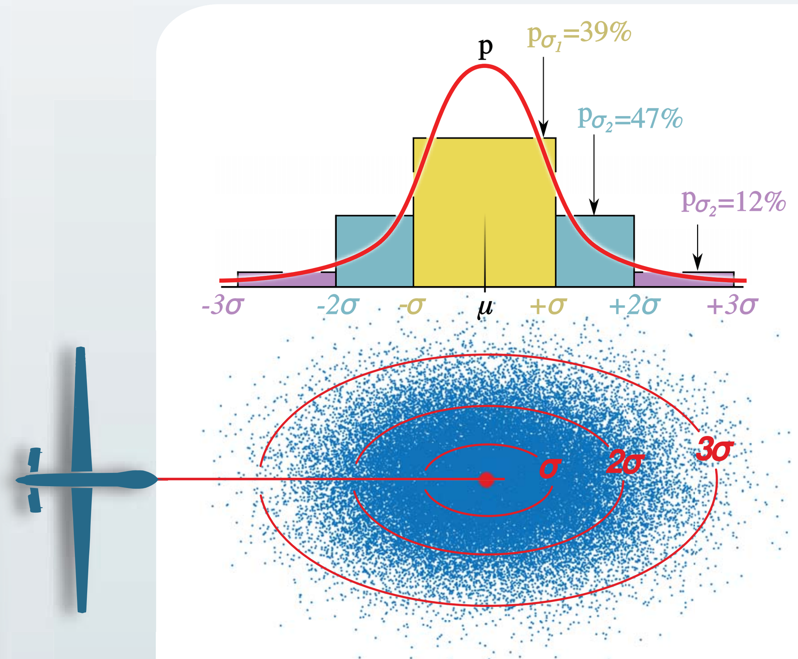
$$\gamma = atan\left(\sqrt{2gh_0}/V_0\right)$$

where $\boldsymbol{V_0}$ is the initial velocity and $\boldsymbol{h_0}$, the inital height.



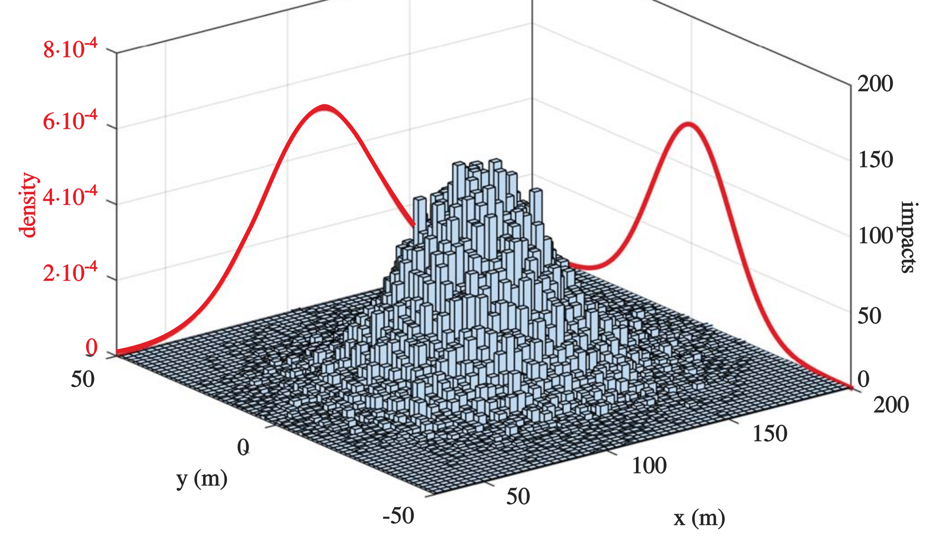
The time $\boldsymbol{t_e}$ that a ground point remains inside the lethal area is equal to the length of the lethal area divided by the velocity $\boldsymbol{V_0}$

Statistical Impact Footprint (SIF)

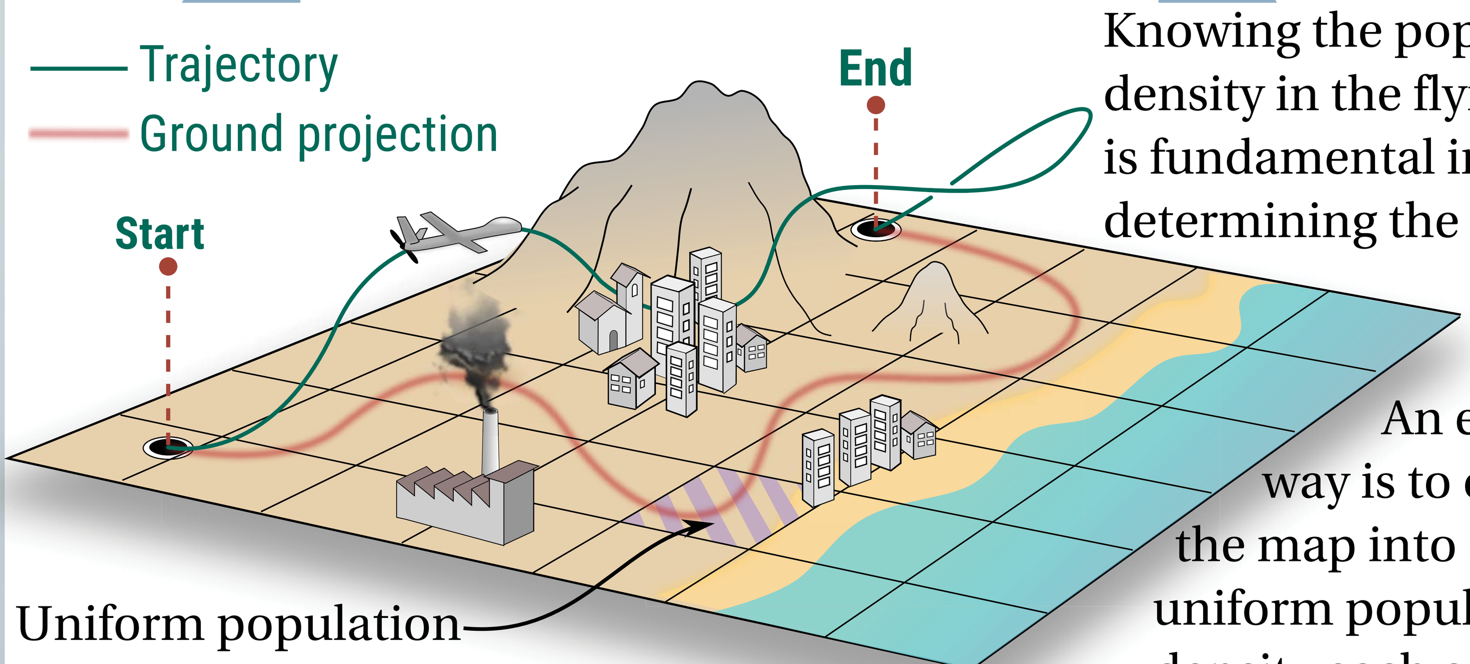


An statistical, impact footprint is obtained considering Gaussian distributed navigation errors over x, y, h, V_x, V_y and V_z through a series of Montecarlo simulations, dividing the impact region into 3 ellipses: σ, 2σ and 3σ

Knowing the probability of impact into each elipse allows weighting the time that a ground point is exposed to the footprint, obtaininig an equivalent exposed time



Grid density map

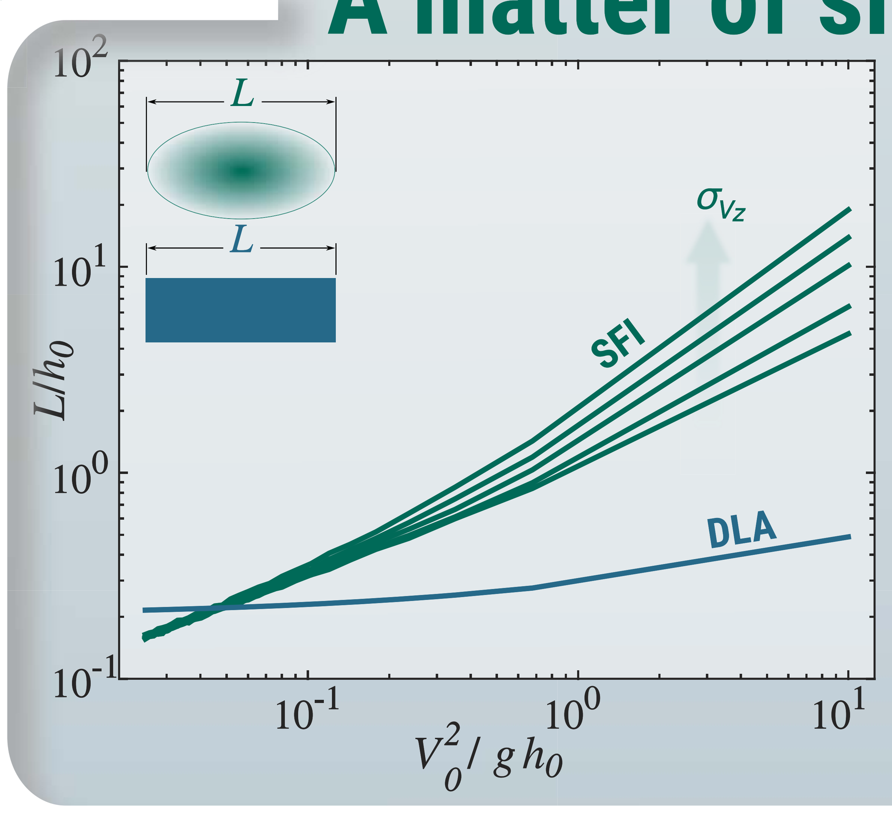


Knowing the population density in the flying area is fundamental in determining the risk

An effective way is to divide the map into cells of uniform population density each one

Uniform population density ρ in each cell (1 ha).

A matter of size

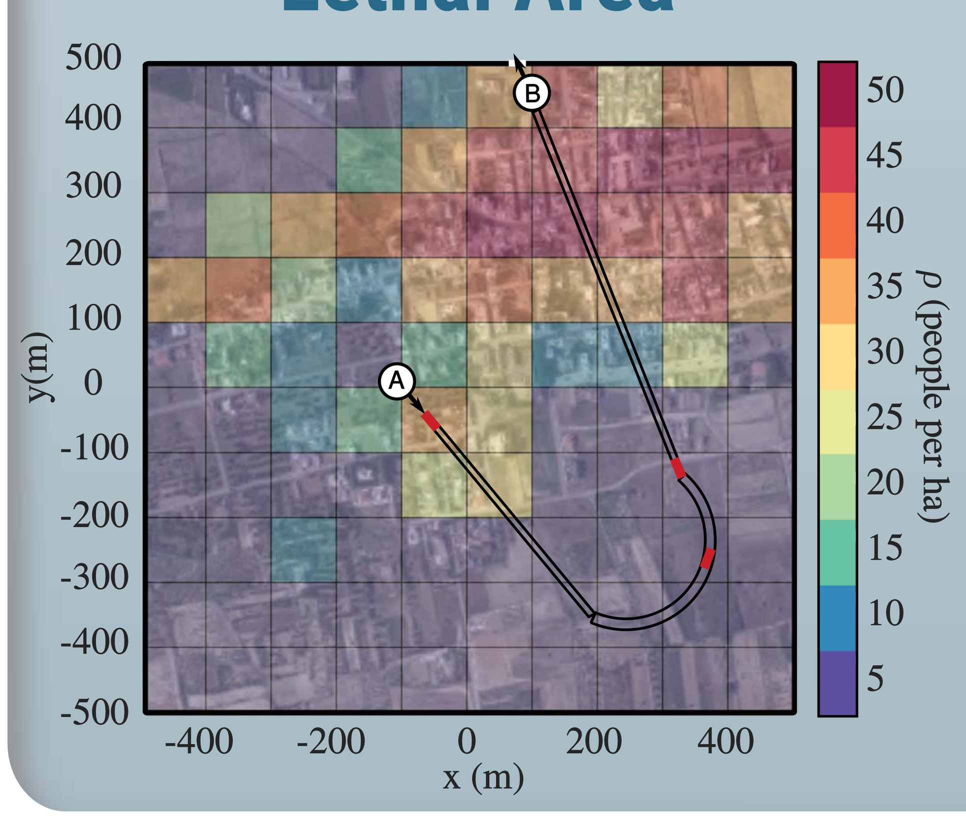


When varying the $V_0^2/\,g\,h_0$ value the length of both **DLA** and **SIF** areas growht. However, the **SIF** length grows much more faster, and the effect of the uncertainty in V_z has a strong effect.

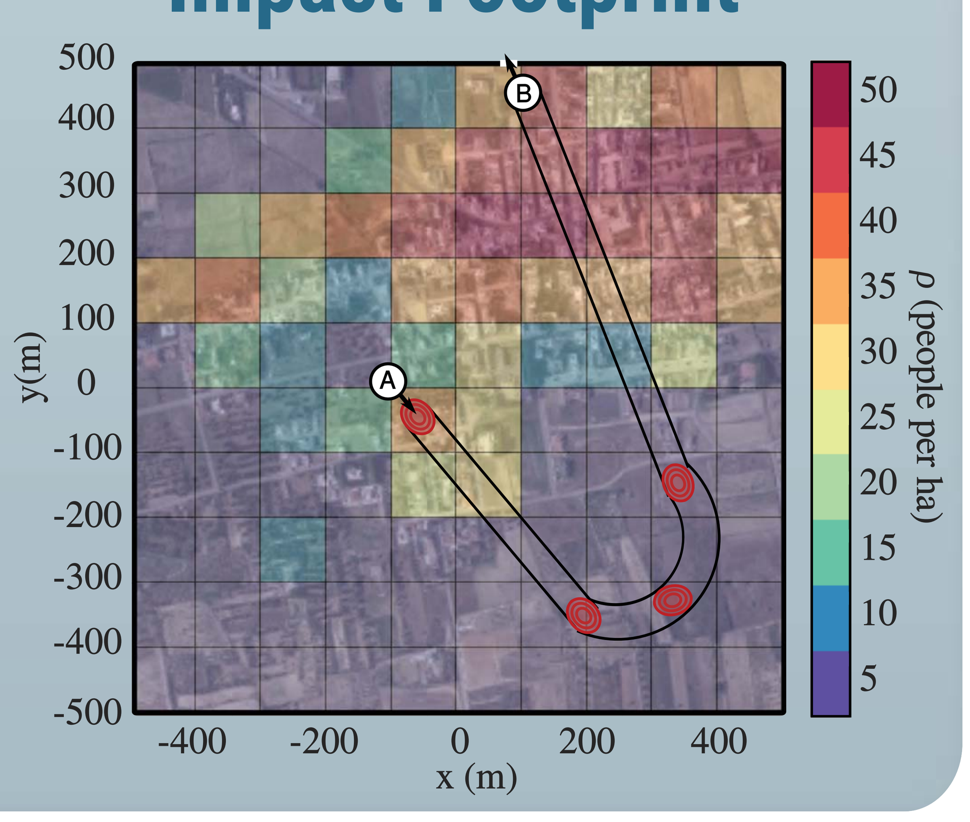
For $\sigma_{Vz}/\,V_z$=0.25 the lenght of the **SIF** area can be 10 times larger than the **DLA**.

Application case

Lethal Area



Impact Footprint



Optimization worflow