SOURCES OF UNCERTAINTIES IN DARK FLIGHT ANALYSES.

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Introduction: In meteorite fall analysis, the dark flight is the last crucial step to predict meteorite fall positions on the ground. Despite the physics involved being relatively well understood, accurately predicting meteorite strewn fields remains a difficult task. With fireball trajectories often precise to <100 m, why is it not possible to get the same precision on meteorite fall positions? The sources of uncertainties broadly fall into three categories:

State vector at the end of bright flight: The last known position and velocity of the meteoroid as seen during the bright phase of the fireball is a necessary starting point for any dark flight integration. Dedicated fireball observation hardware typically produce <100 m precise trajectories. Any position uncertainty translates in at least a 1:1 uncertainty on the ground. A shallow trajectory angles exacerbates any position and velocity uncertainty due to larger projected ellipse.

Physical parameters of the meteorites (mass, density, shape): The uncertainties on the physical characteristics of the stones typically account for a large part of the uncertainty on the ground. The analysis of bright flight fireball data to determine physical parameters of meteoroids is still an active area of research. Depending on the quality of the fireball data available, recent models [1,2] can constrain mass and density to some level. However the precise shape of the stones have a significant influence on fall positions [3], but cannot be derived in the general case from bright flight observations.

Atmospheric conditions throughout the column: A meteorite in dark flight typically spends between 1 and 20 minutes free-falling depending on its characteristics, and is significantly affected by winds during this phase. In order to accurately model the deviation generated by winds, high-resolution weather models are needed. Getting access to these weather models generally requires collaborating with weather scientists, or gain an understanding of weather forecasting tools and their limitations [3]. These models being based on weather observations (including sounding balloons), their accuracy depends on the availability of local observations. In the case of meteorite falls, real-time predictions are generally not required, hence weather models can incorporate observations from before and after the fall. Thanks to the large time and spatial density of weather observations, weather models in developed populated places like Europe are generally accurate to a point where little uncertainty is introduced. In rural Australia, uncertainties on the weather can create add uncertainties of several hundreds of metres on fall positions [4]. In other places with even less measurements, this weather modeling issue could be worse.

Conclusion: Determining an accurate but yet as small as possible ground area to search for meteorites is difficult because of the variety of sources of uncertainty, and how these uncertainties are modeled. Monte Carlo combined approaches are deployed to deal with the various sources of uncertainty [3,5].

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